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Better Site Design: A Correlation Between Quality of Water and Quality of Life

Winford Lee Blackburn
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Winford Lee Blackburn entitled "Better Site Design: A Correlation Between Quality of Water and Quality of Life." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Public Administration.

Bruce Tonn, Major Professor

We have read this thesis and recommend its acceptance:

Teresa Shupp, David Feldman

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Anne Mayhew
Vice Chancellor and
Dean of Graduate Studies

(Original signatures are on file with official student records.)

BETTER SITE DESIGN:
A CORRELATION BETWEEN QUALITY OF WATER AND QUALITY OF LIFE

A Thesis
Presented for the
Master of Science in Planning
The University of Tennessee, Knoxville

Winford Lee Blackburn, Jr.
May 2004

Dedication

This thesis is dedicated to my mentor, Tim Gangaware, whose own dedication to our earth's water resources is a model for anyone who calls himself a steward of the environment, and to my wife, Abby, whose patience shall be rewarded.

"It is my hope that the information presented herein will encourage developers to apply BSD techniques when they become incentivized, and not to despair when they become law."

Acknowledgements

I would like to take this opportunity to thank everyone who played a part in support of attainment of my master's degree. I would especially like to thank my thesis committee: Bruce Tonn, Terry Shupp, and Dave Feldman. Special thanks also goes to Cary Springer who helped me get my survey on the web and who was crucial to the analysis of my data. Lastly, I would like to thank the Center for Watershed Protection for their groundbreaking research and provision of many of the materials that I used as a basis for and incorporated into this paper.

Abstract

The purpose of this thesis is to demonstrate that Tennessee residents would likely find Better Site Design techniques more aesthetically pleasing than conventional land development approaches. Better Site Design is an approach to land development that seeks to reduce impervious cover and maintain a degree of natural vegetation on a development site. This approach has been proven to vastly support healthier water quality of nearby streams and other bodies of water.

The thesis begins with an explication of the Clean Water Act that is the enabling legislation for the National Pollutant Discharge Elimination System. This system mandates communities to incorporate protection of water quality into their operations, plans, and procedures. Better Site Design is an approach to this system that affords water quality support at the post-development stage.

A description of Better Site Design is offered followed by the scientific evidence that supports the fact that it does, indeed, aid water quality. Finally, the detail of a survey developed and implemented by the author is presented. The survey depicts a graphical comparison of two approaches to land development in terms of stormwater management: the conventional approach and the Better Site Design approach. There are 12 scenarios in which the two approaches are compared. Each scenario consists of a graphical comparison of the Better Site Design technique with its conventional counterpart.

Results of the survey show an overwhelming agreement with my hypothesis. Better than 90% of those surveyed showed agreement with 10 of the 12 scenarios, and at least 63% showed agreement with the other two scenarios. In all cases, the chi-square test demonstrates significance of respondents answering in agreement, considerably more than 50% of the time.

Given the survey results, it is concluded that developments incorporating Better Site Design would be feasibly marketable and sellable by land developers, and would also enhance local water quality.

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CHAPTER 1
INTRODUCTION

Is there a correlation between water quality and visual preference in regards to "Better Site Design?" This is the driving question behind the thesis: "Better Site Design: A Correlation Between Quality of Water and Quality of Life." In other words, does site design that serves to promote water quality have a positive correlation with visual preferences of community life? First, three terms from the above should be defined. Water quality is defined here as the standard of quality for surface waters (streams, lakes, and rivers) in terms of pollutant load, including nutrients, toxins, and sediment; and physical characteristics affecting habitat. Secondly, quality of life is defined as a person's subjective interpretation of the condition of their life. Here, the elements of life quality emphasized are facets of their dwelling situation--specifically, the visual quality of the community in which they live. Finally, Better Site Design (BSD) is defined as a means of designing a subdivision, commercial property, or any tract of land that ultimately incorporates protection of proximal surface waters through techniques that promote decreased pollutant loads in stormwater runoff.

Scientific evidence exists that proves BSD techniques do, in fact, reduce pollution in stormwater runoff. The purpose of the thesis is to deduce if home buyers would show such a preference for communities that employed such techniques, in terms of aesthetic value and sense of place, and therefore enhanced quality of life.

This study is in response to legislation of the Federal Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The United States Environmental Protection Agency (EPA) is charged with enforcement of the CWA. The EPA has developed guidelines for communities to improve proximal surface water quality. In an effort to do so, local stormwater management teams have developed strategies that would aid in the accomplishment of this goal. One such strategy involves the aforementioned ideal of Better Site Design. From personal experience with the implementation of the

CWA, it is evident that there are strongly held beliefs by many in the development community that these BSD techniques will add to the cost of the development, thereby detracting from the overall profitability and economics thereof. Because of these beliefs, some avoid incorporating such practices into their developments and are hostile towards any efforts by municipalities to force this approach. The importance of this study comes in the form of encouragement to land developers to use more environmentally friendly development techniques in regards to site design; specifically, the use of development techniques that would set the stage for greatly improved water quality in terms of reduced pollutant loads in stormwater runoff.

Currently, Knox County developers have shown a general hesitance in applying techniques such as these. In fact, no employment of these techniques is apparent in Knox County at a significant scale. However, many communities across the country have implemented such designs, and they have been well received. If developers in Tennessee received data that would suggest a preference for development that utilized this approach (or some dimension thereof), one could conclude that they would be more likely to actually structure designs that would incorporate these techniques.

This thesis begins with a background of BSD, including the authoring body, general environmental implications in terms of water quality, and specific examples. This is followed by a discussion of the CWA and subsequent policies and programs that provide a basis for employment of BSD techniques, specifically the National Pollutant Discharge Elimination System. This section is followed by scientific data and explanations of the general environmental implications that qualify BSD as theoretically serving as a means of reducing pollution in stormwater runoff, and thereby reducing the pollution input into local surface waters. In other words, BSD is a strategy that can be employed to enhance local water quality. Finally, the results of a survey developed and implemented by the author are incorporated into the paper to show that people would find BSD techniques more aesthetically pleasing than conventional land development standards, and thus would be more likely to purchase property that incorporated such. The methodology and

details of the study are presented as a corollary of that section. Finally, a conclusion is offered that supports the original hypothesis.

CHAPTER 2
BETTER SITE DESIGN

While the fundamental elements of Better Site Design (BSD) have already been established, a background of the concept will be provided including a solid definition, and information about the authority on BSD will be provided. This will be followed by the specific "Model Development Principles" that were endorsed by the national site planning roundtable (SPR) and a discussion of the Knox County SPR process that has acted as the driver for this study.

2.1 Background

More than 1.5 million acres of land are developed each year in the U.S. This development alters the surface of the land in numerous ways. Primarily, natural cover is replaced by surfaces such as roads, parking lots, and other surfaces that are impermeable to rainfall. These surfaces are also known as impervious.[1] To reiterate, impervious surfaces have a significant negative impact on local waters that receive the runoff from them. More detail and explication of this topic will be provided in the next chapter. BSD is an approach to land development that is easily construed as being more environmental friendly, especially in regards to water quality. "It seeks to accomplish three goals at every site: to reduce the amount of impervious cover, to increase natural lands set aside for conservation, and to use pervious areas for more effective stormwater treatment."[2]

The frontrunner in watershed protection in the U.S. and subsequently the authority on BSD is the Center for Watershed Protection (CWP), founded in 1992 and based in Ellicott City, MD. The CWP is a not for profit organization committed to protecting our

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[1] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 1.

[2] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 623.

country's lakes, rivers, and streams. It provides local governments, activists, and watershed groups around the country with technical tools to protect these precious natural resources. The CWP has developed and disseminated a multi-disciplinary strategy to watershed protection that encompasses elements such as watershed planning and restoration, stormwater management, education and outreach, and watershed management training. CWP credits include:

- Launching 5 local Site Planning Roundtables
- 10 state stormwater manuals
- 20 plans to protect/restore local watersheds
- 30 watershed research projects
- 150 articles on the latest techniques for watershed protection
- Training 15,000 individuals through watershed workshops[3]

2.2 The National Site Planning Roundtable and Model Development Principles

The purpose of this study is to show that BSD techniques are more aesthetically pleasing than conventional ones in an effort to encourage land developers to apply them in their developments. Developers in Knox County and elsewhere have been extremely hesitant in exploring the use of these principles. The primary reason for this is the mostly outdated development rules that govern the land development process. These rules include subdivision codes, zoning regulations, parking and street standards, and drainage regulations that collectively seem to work against the ideals of BSD. "Few developers are willing to take risks to bend these rules with site plans that may take years to approve or that may never be approved at all."[4]

However, with development rules essentially prohibiting application of some of the BSD techniques, a strategy was developed in an effort to change the rules. In 1997, a national

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[3] www.cwp.org/mission.htm 18 February 2004, 8:30 AM.

[4] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 623.

site planning roundtable (SPR) was convened to address ways to encourage BSD in more communities. Table 2.1 is a list of participants in this national SPR.

As you can see, the convention represented diverse groups that are intimately involved with the development process in some capacity. These groups were able to provide technical and working experience to make BSD possible. The national SPR lasted approximately two years, and endorsed 22 "Model Development Principles" at the termination of the project. The principles offer specific guidance that can help achieve the ideals of BSD. The techniques are not strict guidelines, but a basis for local communities to apply BSD. The "Model Development Principles" are categorized as follows:

(1) Residential Streets and Parking Lots

(2) Lot Development

Table 2.1 Organizations Represented at the 1997 National Site Planning Roundtable[5]

NATIONAL SPR ORGANIZATIONS	
American Association of State Highway Transportation Officials	Land Trust Alliance
American Forest Association	Linowes & Blocher
American Institute of Architects	Loiederman Associates, Inc.
American Planning Association	Michael T. Rose Company
American Public Works Association	Montgomery County Council
American Rivers	Natelli Communities
American Society of Civil Engineers	National Association of Home Builders
American Society of Landscape Architects	National Realty Committee
Chesapeake Bay Program	Natural Resources Defense Council
Community Associations Inc.	Prince Georges County, Department of Environmental Resources
The Conservation Fund	U.S. EPA, Office of Sustainable Ecosystems and Communities
Office of Comprehensive Planning, County of Fairfax, VA	U.S. Fire Administration
Howard Research and Development Corporation	Urban Land Institute
International City/County Management Association	Urban Wildlife Resources
	Institute of Transportation Engineers

[5] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 624.

(3) Conservation of Natural Areas

The "Model Development Principles," as set forth at www.cwp.org/22_principles.htm, follow. I will expound on those principles that are addressed later in my survey.

Residential Streets and Parking Lots (Habitat for Cars)

It is estimated that as much as 65% of the total impervious cover in a given landscape can be classified as "habitat for cars." This cover includes streets, driveways, parking lots, etc. There are 10 BSD techniques that address this issue:

1. *Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.*

It is not uncommon that street widths are required to be 36 feet or more in width regardless of the traffic volume involved. This is partially due to the perceived need to supply on-street parking and unobstructed access for fire trucks. In fact, residential streets are usually unnecessarily wide making them the largest single component of impervious cover in a subdivision.[6] Communities have a great opportunity to significantly reduce this impervious cover by revising their street standards to widths that are more consistent with the volume of traffic they must handle. Street width reduction can be applied in numerous instances and still provide adequate parking and ensure access for service, maintenance, and emergency vehicles.[7] Several national engineering organizations have recommended that residential streets can be as narrow as 22 feet if they serve neighborhoods that produce low traffic volumes (less than 500 daily trips or 50 homes). Table 2.2 offers examples of communities that have successfully implemented narrower street widths.

2. *Reduce the total length of residential streets by examining alternative street layouts to*

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[6] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 29.

[7] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 624.

Table 2.2 Examples of Narrower Residential Street Widths[8]

Source	Width	Max Avg. Daily Traffic
State of New Jersey	20' (no parking) 28' (parking on one side)	0-3500 0-3500
Boulder, CO	20' 20' (no parking) 22' (one side) 26' (both sides) 26' (one side)	150 350-1000 350 350 500-1000
Bucks County, PA	12' (alley) 16-18' (no parking) 20-22' (none) 26' (one side) 28' (one side)	-- 200 200-1000 200 200-1000

determine the best option for increasing the number of homes per unit length.

3. *Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.*

4. *Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.*

A cul-de-sac is a street open only on one end, usually with a turnaround bulb at the closed end. Many communities require this bulb to be 50-60 feet in radius to allow for emergency vehicle turnaround. This creates a large tract of unnecessary impervious area. One remedy for this is to install a planted pervious island in the center of the cul-de-sac, creating a donut-like effect. The center of the cul-de-sac is seldom used—vehicles travel directly in the center.[9]

5. *Where density, topography, soils, and slope permit, vegetated open channels should be*

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[8] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 29.

[9] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 625.

used in the street right-of-way to convey and treat stormwater runoff.

"Streets contribute higher loads of pollutants to urban stormwater than any other source area in residential developments." The sources of pollutants include vehicle emissions, pet waste, lawn and garden runoff, and tire and brake pad wear, among many others. Most communities require that curb-and-gutter systems be installed along residential streets to collect and convey stormwater runoff away from the source, and quickly direct it to nearby streams. Contrastingly, the use of vegetated open channels or swales offers excellent treatment opportunities to stormwater by allowing infiltration, filtering, and slowing its conveyance.[10]

6. *The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible*.

7. *Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.*

8. *Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas where possible*.

Here I will focus on spillover/overflow areas. It is noted that parking lots are much larger than necessary to accommodate its users. Currently in Knox County there are minimum requirements for parking lot sizes. Often times a developer will greatly exceed this minimum size requirement. Also, stall sizes are much larger than necessary. That said, one way to reduce impervious area on a lot that is already larger than necessary is to use pervious materials in the overflow parking area. The overflow parking area is the area further away from the structures being visited that is used during busier times such as Saturdays or during the holiday season. This area is significantly less used than the main parking areas. Pervious materials that can be used include porous paving materials and even turf.

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[10] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 55-56.

9. *Provide meaningful incentives to encourage structured and shared parking to make it more economically viable*.

10. *Wherever possible, provide stormwater treatment for parking lot runoff using bio-retention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.*

Parking lots are a significant source of stormwater pollutants, especially in commercial areas. This fact is attributed to the source and magnitude of these pollutants. Many vehicles use commercial parking areas. In doing so, they deposit debris from wear and tear, emissions, and leakage. Bannerman documented the significance of parking lot runoff. His study showed that for commercial and particularly industrial land uses, parking lots are a critical source of stormwater pollution. Parking lot runoff accounted for one-fourth to two-thirds of the suspended solids, total phosphorous, total copper, and total zinc loads in the commercial and industrial areas studied.[11] One way to treat the polluted stormwater before it leaves the site is to install planted or landscaped islands in the parking area(s). This could be taken a step further and these islands could be developed into miniature stormwater treatment facilities, including bio-retention facilities, filter strips, and perimeter sand filters. However, there should at least exist the opportunity for some filtering supplied by planted islands.

Lot Development (Habitat for People)

There are many opportunities for stormwater treatment and impervious surface reduction by modifying the shape, size, and layout of residential lots. Also, different treatments exist that can be applied at the level of lot design. There are 6 BSD techniques that address this level of application.

11. *Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.*

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[11] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 83-84.

Open space development is also known as cluster development/design. This type of design clusters houses into a smaller portion of the development site, leaving more of the site as natural open space. These types of subdivisions have been documented to reduce impervious cover, stormwater runoff, and construction costs, and offer more opportunities for stormwater treatment through filtering in the open space. Clustering the development reduces road lengths and consequently impervious cover. This type of development may not be feasible in denser residential zones, but should be allowable as a development option. Currently, this type of design is often prohibited or severely restricted by local zoning regulations.[12]

12. *Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.*

13. *Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas*.

Most sidewalk design codes require that sidewalks be constructed of concrete or asphalt and be from 4 to 6 feet wide.[13] While these codes are designed for safety and accommodation, they should offer more flexibility. Sidewalks should be allowed to be constructed with pervious materials at the developer's discretion. Also, widths could be greatly reduced and still provide an adequate pedestrian travel way. Placing a sidewalk directly adjacent to the street should be discouraged all-together, and flexibility should be added and incentives provided to encourage placement of more mature vegetation between the sidewalk and road, such as larger trees. This would offer increased stormwater treatment opportunities and would also provide an extra element of safety as a barrier between the pedestrian and traffic.

14. *Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.*

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[12] "An Introduction to Better Site Design." Article 45, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 627.

[13] Ibid.

Many subdivision codes are not explicit as to how driveways should be designed beyond the apron connecting the driveway to the street. The width and surface material are usually left unaddressed. "As much as 20% of impervious cover in a residential subdivision consists of driveways." This amount of imperviousness can be reduced by encouraging or requiring driveways to be made of pervious materials, two-track driveways with a center pervious strip, and reducing their widths.[14]

15. *Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.*

16. *Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.*

Conservation of Natural Areas (Habitat for Nature)

Preservation of natural areas is crucial to BSD. The final six techniques address conserving and managing natural areas on the level of site design.

17. *Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands*.

Stream buffers should be used for two reasons. First, they should exist to regulate the type and location of development within the floodplain of a stream. Secondly, they offer protection to the water quality of streams, especially if the stream has been designated as providing drinking water or unique aquatic habitat. Upon these designations, the stream buffer width should be at least 100 feet.[15] However, at least, developers should be discouraged from clearing the site all the way to the stream bank. Some mature vegetation left in proximity to or on the bank will serve to stabilize the bank and offer increased filtering opportunities as runoff enters the stream directly.

18. *The riparian stream buffer should be preserved or restored with native vegetation.*

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[14] Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection, Ellicott City, MD. August 1998. p. 115.

[15] Ibid, 129.

The buffer system should be maintained through the plan review delineation, construction, and post-development stages.

19. *Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.*

20. *Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas.*

It is rare that a community will require a certain percentage of mature natural vegetation to be left on a site. Further, many communities promote the use of the lawn monoculture to encompass most of the site. Native and mature trees, shrubs, and grasses contribute significantly to environmental health. Those particular species were put there for a reason, and are tolerant to the conditions thereof. They serve to stabilize the ground, and more mature vegetation increases the filtering opportunities of stormwater runoff to a high degree.

21. *Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.*

22. *New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.*

2.3 Knox County Site Planning Roundtable

Based on the research and the foregoing principles set forth by the national SPR and the CWP, Knox County, under the guidance of the Stormwater Coordinator, has ventured to develop its own local SPR in an effort to change the development rules there. Members

of the Knox County SPR include several local land development firms, engineers, utility representatives, environmental activists, planners, scientists, and local officials, among many others.

The SPR began as one large group and subsequently divided itself into smaller work groups. The groups were categorized into "Streets and Parking," "Lot Design," "Open Space," and "Development Process." These groups met as subcommittees of the SPR, and used the Model Development Principles as guidance to develop their own BSD principles based on local needs, desires, and constraints. Currently in its second year, the Knox County SPR has gained consensus on 21 of the 22 model development principles that were revised to meet local needs. At this time, the Knox County SPR is developing a strategy to gain approval from the County Mayor and County Commission, in order to apply its own BSD principles to local codes and ordinances.

It is from the Knox County SPR that the notion of land developers' general hesitance to apply BSD techniques has arisen. As part of the SPR, I witnessed this hesitance first hand in the form of persistent negative connotations applied to BSD by these developers. From my experience, the developers seemed to believe that BSD would throw their operations into upheaval: they would have to change the way they do things and what they have become conditioned to. The application of the designs that they have used for years may no longer be appropriate at the same scale. Even having gained consensus on most of the principles as set forth by the Knox County SPR, I sensed general negativity about BSD from the developers in the process. The importance of this study is portrayed in these facts. My purpose is to offer some encouragement to these developers through the fact that BSD techniques are more aesthetically pleasing, and would be worthy and profitable to apply to their developments. Not only would they benefit local water quality, they would have the potential to benefit their businesses.

CHAPTER 3
THE CLEAN WATER ACT

The Clean Water Act (CWA) is a body of law that was created in reaction to large-scale industrialization. Where previously anything could be discharged into "waters of the United States" without consequence, the CWA has established regulations that seek to prevent further harm and even improve said waters. This section offers a background of the CWA, a review of the sections of the act that provide for the NPDES program (i.e. authority), and a description of the National Pollutant Discharge Elimination System (NPDES) which is a cornerstone of the act. Further, a brief discussion of how the NPDES relates to BSD will ensue.

3.1 Background

The CWA began as the Federal Water Pollution Control Act, and in1972 amendments were made in response to growing public awareness and general concern for controlling water pollution. This law became known as the Clean Water Act, as amended in 1977. The CWA established the basic structure for regulating discharges of pollutants into the waters of the United States. It does not deal directly with ground water nor water quantity issues. The statute employs many regulatory and non-regulatory tools to vastly reduce direct pollutant discharges into waterways and to manage polluted runoff. "These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support 'the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.'"[16]

It provided the Environmental Protection Agency the authority to implement pollution control programs such as benchmarking wastewater standards for industries that discharge pollutants into surface waters as part of their regular operations. The CWA

[16] www.epa.gov/watertrain/cwa/ 11 February 2004, 3:55 PM.

also made it illegal to discharge any pollutant from a point source into navigable waters, unless a permit was first approved and obtained. The CWA also recognized the necessity of planning to address the paramount problems caused by non-point source pollution.[17]

Point source pollution is defined as pollution that can be traced to a specific point of origin (e.g. an industry that uses water from a river for its operations and discharges the used water back into the river). Non-point source pollution is defined as pollution that has no discernable origin (e.g. stormwater runoff that is carrying toxins). However, if this polluted stormwater runoff is directed to a conveyance system via ditches, culverts, channels, or gutters then discharged directly to a stream, it is deemed point source.

Evolution of the CWA programs over the last decade has procured a shift from a "program-by-program, source-by-source, pollutant-by-pollutant approach" to a more regional approach. This regional approach is known as the watershed approach.[18] A watershed is defined as the area of land that drains its stormwater runoff to a particular body of water, usually a stream. For example, all of the land that contributes its stormwater runoff to the Tennessee River is known as the Tennessee River Watershed. Equal emphasis is placed on protecting healthy waters and restoring impaired ones. A diverse body of issues is addressed in terms of approaching problems and protection measures, not just those under direct CWA regulatory authority. "Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining state water quality and other environmental goals is another hallmark of this approach."[19]

3.2 Authority

Like most legislation in the U.S., the CWA contains many details and extraneous information. The purpose of this section is to highlight segments of the CWA that serve

[17] www.epa.gov/r5water/cwa.htm 11 February 2004, 3:40 PM.
[18] www.epa.gov/watertrain/cwa/ 11 February 2004, 3:55 PM.
[19] www.epa.gov/watertrain/cwa/ 11 February 2004, 3:55 PM.

as a basis for the creation of the NPDES program.

Section 101 of the Federal Water Pollution Control Act (hereinafter called the "Act") provides a declaration of its goals and policy. The information related to the development of the NPDES program will be extracted and presented.

> (a) The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. In order to achieve this objective it is hereby declared that, consistent with the provisions of this Act—
>
> > (1) it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985;
> >
> > (2) it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983;
> >
> > (3) it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited...
> >
> > (7) it is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.
>
> (b) It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this Act.

Section 102 of the Act offers information in regards to comprehensive programs for water pollution control. The information related to the development of the NPDES

program will be extracted and presented here.

> (a) The Administrator shall, after careful investigation, and in cooperation with other Federal agencies, State water pollution control agencies, interstate agencies, and the municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters. In the development of such comprehensive programs due regard shall be given to the improvements which are necessary to conserve such waters for the protection and propagation of fish and aquatic life and wildlife, recreational purposes, and the withdrawal of such waters for public water supply, agricultural, industrial, and other purposes.
>
> (c) (2) Each planning agency receiving a grant under this subsection shall develop a comprehensive pollution control plan for the basin or portion thereof which—
>
> (A) is consistent with any applicable water quality standards, effluent, and other limitations, and thermal discharge regulations established pursuant to current law within the basin;
>
> (B) recommends such treatment works as will provide the most effective and economical means of collection, storage, treatment, and elimination of pollutants and recommends means to encourage both municipal and industrial use of such works;
>
> (C) recommends maintenance and improvement of water quality within the basin or portion thereof and recommends methods of adequately financing those facilities as may be necessary to implement the plan;
>
> (D) as appropriate, is developed in cooperation with, and is consistent with any comprehensive plan prepared by the Water Resources Council, any area-wide waste management plans developed pursuant to section 208 of this Act, and any State plan developed pursuant to section 303(e) of this

Act.

(3) For the purposes of this subsection the term “basin” includes, but is not limited to, rivers and their tributaries, streams, coastal waters, sounds, estuaries, bays, lakes, and portions thereof, as well as the lands drained thereby.

Section 104 of the Act describes information on research, investigations, training, and information. The information related to the development of the NPDES program will be extracted and presented here.

(p) Municipal and Industrial Stormwater Discharges—

(3) Permit Requirements—

(B) Municipal Discharge—Permits for discharges from municipal storm sewers—

(iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

(6) Regulations—

...The program shall, at a minimum, (A) establish priorities, (B) establish requirements for State stormwater management programs, and (C) establish expeditious deadlines. The program may include performance standards, guidelines, guidance, and management practices and treatment requirements, as appropriate.

3.3 National Pollutant Discharge Elimination System

One program established by the CWA is the National Pollutant Discharge Elimination System (NPDES). The NPDES has been a major factor in the nation's effort to protect its surface waters. Thirty years ago, only one-third of our waters were considered healthy. Today, almost two-thirds are healthy. Again, this provides for a wide range of environmental, recreational, and economic benefits to millions of United States citizens.[20]

The NPDES was introduced in 1972 and growth of the program occurred in 1987 with reauthorization of the CWA. The NPDES regulates the discharge of pollutants into the waters of the U.S. through permits that are issued to industrial, municipal, and other point source dischargers. This regulation is handled by the EPA or an authorized state in collaboration with the EPA. Beyond the scope of stormwater, several hundred thousand businesses and more than 16,000 municipal sewage treatment systems comply with standards set forth in NPDES permits. The typical point sources regulated under the system are municipal wastewater systems, municipal and industrial stormwater systems, industries and commercial facilities, and concentrated animal feeding operations.[21] For the purposes of this paper, the focus will be on municipal stormwater systems.

As mentioned earlier, the permitting system may be handled by an authorized state. Currently, 44 states are authorized to handle the NPDES permits therein. State implementation is fundamental to the system and the CWA because it allows state managers to set priorities and shape the program to meet specific challenges posed to the waters of the state based on local land uses. Also, it allows the state to satisfy the needs and wants of its own citizens to some extent, which sets the stage for good working relationships with land owners and business operators. It prevents blanket regulations that may not be in the best interest of the state or the management scheme. However, the

[20] "Protecting the Nation's Waters Through Effective NPDES Permits: A Strategic Plan, FY 2001 and Beyond". United States Environmental Protection Agency, Office of Water, Washington, DC. June 2001. (From "Strategic Outlook").

[21] Ibid, 1.

EPA does work closely with the states to ensure a degree of consistency and to help states meet environmental objectives.[22] The regulating authority in the state of Tennessee is the Tennessee Department of Environment and Conservation (TDEC). "State administered programs promote day-to-day decision making at a level more attuned to the situation in individual watersheds." EPA's role is to provide management tools, technical assistance, and guidance in an effort to support the state's implementation of the NPDES program.[23]

As per the 2001 Strategic Plan, there are specific goals set forth that the EPA is charged with accomplishing. The NPDES program directly supports the second goal of EPA's overall strategic plan, which is entitled "Clean and Safe Water." There are two specific objectives related to the NPDES program. The first objective is "By 2005, increase by 175 the number of watersheds where 80 percent or more of assessed waters meet water quality standards." The result of this objective would be "By 2005, 5,000 additional miles of water will attain water quality standards and specific interim milestones will be achieved in 50,000 impaired miles." The second objective is "By 2005, reduce pollutant loadings from key point and non-point sources by at least 11 percent from 1992 levels." The result of this objective would be "By 2005, using both pollution control and prevention approaches, reduce at least 3 billion pounds of pollutant source loadings from key sources including combined 11 percent reduction from industrial sources, publicly owned treatment works (POTW), and combined sewer overflows."[24]

The NPDES program has several program areas within its focus. These areas are animal feeding operations, combined sewer overflows, pretreatment, sanitary sewer overflows, and stormwater. Again, the focus of this paper is on stormwater. As part of the NPDES permitting program, two phases in regards to stormwater pollution reduction have been created and implemented. They are aptly named the Phase I and Phase II Stormwater programs. These programs address and require permits for stormwater discharges at all

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[22] "Protecting the Nation's Waters Through Effective NPDES Permits: A Strategic Plan, FY 2001 and Beyond". United States Environmental Protection Agency, Office of Water, Washington, DC. June 2001. p. 2.
[23] Ibid, 10.
[24] Ibid, 3.

levels, including construction activities, industrial activities, and municipal separate storm sewer systems (MS4's). The focus of this paper is on MS4's. "An MS4 is defined as any conveyance or system of conveyances that is owned or operated by a state or local government entity designed for collecting and conveying storm water which is not part of a POTW."[25]

Phase I of the program was established in 1990 and requires municipal operators of "medium" and "large" MS4's to implement a storm water management program as a means of controlling polluted discharges from these systems. "Medium" and "large" MS4's are those that serve municipalities with a population of 100,000 or greater. Phase II of the program extends coverage to certain "small" MS4's and takes a slightly different approach to how the storm water management program is developed and implemented. A "small" MS4 is one that is not already covered by the Phase I program as medium or large.[26]

"Pollutants in stormwater discharges continue to remain a significant source of environmental impacts to the quality of waters of the United States." The "National Water Quality Inventory, 1994 Report to Congress" provides a general assessment of water quality based on biennial reports submitted by states under Section 303(b) of the CWA. The Report indicates that storm water discharges from a variety of sources including separate storm sewers are major causes of water quality impairment. One example is of a survey carried out on estuaries, where 46 percent of the identified cases of water quality impairment were attributable to storm sewer runoff.[27]

"Polluted storm water runoff is often transported to MS4's and ultimately discharged into local streams and rivers without treatment." In this section, the focus will be on the

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[25] "Overview of the Storm Water Program". United States Environmental Protection Agency, Office of Water, Washington, DC. June 1996. p. 4.

[26] "Storm Water Phase II Final Rule: Small MS4 Storm Water Program Overview". United States Environmental Protection Agency, Office of Water, Washington, DC. January 2000, Fact Sheet 2.0. p.1.

[27] "Overview of the Storm Water Program". United States Environmental Protection Agency, Office of Water, Washington, DC. June 1996. p. 4.

Phase II program, being a member of a Phase II community (Knox County). Also, my work with Better Site Design has arisen from my involvement with the Knox County Site Planning Roundtable, a group committed to addressing Phase II issues as they relate to land development. I mention these facts so as to provide an understanding of my exclusion of further Phase I mention. EPA's Phase II Rule establishes an MS4 storm water management program that is intended to improve waters of the U.S. by reducing the quantity of pollutants that storm water picks up and transports to storm sewer systems during storm events. Common pollutants are petroleum products from roadways, nutrients and pesticides from lawns and landscapes, sediment from non-vegetated tracts of land, and carelessly discarded trash. When these pollutants are discharged into local bodies of water, there are many detrimental implications. Recreational use is discouraged, drinking water may become contaminated, and habitat for fish, aquatic organisms, and other wildlife may be harmed and even destroyed.[28]

Operators of small MS4's that are regulated under the Phase II NPDES permit are required to "reduce the discharge of pollutants to the 'maximum extent practicable', protect water quality, and satisfy the appropriate water quality requirements of the CWA." To implement the "maximum extent practicable" standard, development and implementation of Best Management Practices (BMP's) are typically required. BMP's are defined as measures, structural or not, that can be implemented to reduce pollutant loads in stormwater runoff. Also the achievement of measurable goals to satisfy each of the six minimum control measures will be necessary. "The Phase II Rule defines a small MS4 storm water management program as a program comprising six elements that, when implemented in concert, are expected to result in significant reductions of pollutants discharged into receiving water bodies."[29]

The six MS4 program elements or "minimum control measures" are: (1) public education

[28] "Storm Water Phase II Final Rule: Small MS4 Storm Water Program Overview". United States Environmental Protection Agency, Office of Water, Washington, DC. January 2000, Fact Sheet 2.0. p.1.

[29] Ibid.

and outreach, (2) public participation and involvement, (3) illicit discharge detection and elimination, (4) construction site runoff control, (5) post-construction runoff control, and (6) pollution prevention/good housekeeping. In other words, the operator of a Phase II regulated MS4 is required to include these elements in its storm water management program in order to meet the conditions of its NPDES permit.

3.4 NPDES v. Better Site Design

To describe the relationship between the NPDES program and BSD, I will refer to the previous section. The direct relationship between the NPDES program and BSD is apparent in the fifth MS4 program element as stated above: Post-Construction Runoff Control. This section will offer more detail on this program element and how it relates to the principles of BSD.

The description of the Post-Construction Runoff Control element follows:

> "Developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from NEW development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas (e.g. wetlands) or the use of structural BMP's such as grassed swales or porous pavement."[30]

The following outlines the Phase II Final Rule requirements for post-construction runoff in some detail, including why it is necessary in terms of pollution control, what exactly is required, and some guidelines for implementation.

Runoff from newly developed and redeveloped areas has been shown to significantly affect the waters into which it flows. Many studies indicate that pre-development

[30] "Storm Water Phase II Final Rule: Small MS4 Storm Water Program Overview". United States Environmental Protection Agency, Office of Water, Washington, DC. January 2000, Fact Sheet 2.0. p. 2.

planning and design for the reduction of pollutants in post-construction stormwater discharges is the most cost-effective approach to stormwater quality management.[31]

There are basically two forms of significant impacts of post-construction runoff. The first is caused by an increase in the amount and type of pollutants in the runoff at this stage. Development alters the character of the land from its original or pre-development state. Post-development characteristics generally increase the quantity of water that is discharged to surface waters after storms. This is due to the increase in impervious surfaces, such as asphalt and concrete that are common as a result of land development. Impervious is simply defined as the inability to allow water to infiltrate, thereby forcing all of the water that comes into contact with it to runoff. Imperviousness not only increases the volume of runoff but the velocity as well. Increased impervious surfaces disrupt the natural cycle of water's gradual percolation and infiltration into the soil structure and vegetation. It also has other implications that will be described later. Additionally after development, much is present that was not previously, due to the presence of machinery and humans in general (e.g. petroleum products from cars, sediment from non-vegetated earth, pesticides and nutrients from lawns and gardens, and even heavy metals, among others). These pollutants are easily suspended in storm water after a rain event and transported to neighboring bodies of water. Again, once these pollutants enter a lake or stream, they are easily introduced into the tissues of aquatic life and even humans.[32]

The Phase II Final Rule requires an operator of a regulated (permitted) MS4 "to develop, implement, and enforce a program to reduce pollutants in post-construction runoff to their MS4 from new development and redevelopment projects that result in the land disturbance of greater than or equal to one acre." Four things are required of the operator. They are to (1) develop and implement strategies which include a combination

[31] "Storm Water Phase II Final Rule: Post-Construction Runoff Control Minimum Control Measure". United States Environmental Protection Agency, Office of Water, Washington, DC. January 2000, Fact Sheet 2.7, p. 1.

[32] Ibid, 1.

of structural and/or non-structural BMP's, (2) have an ordinance or other regulatory mechanism requiring implementation of post-construction runoff controls to the extent allowable under State, Tribal, or local law, (3) ensure adequate long term operation and maintenance of controls, and (4) determine the appropriate BMP's and measurable goals for this minimum control measure.[33]

BSD is a method of approaching land development that incorporates the use of BMP's, both structural and non-structural. Examples of non-structural BMP's include planning and procedures and site-based local controls. Sound planning is very effective at addressing runoff problems. Examples of planning controls are zoning ordinances, comprehensive, and master plans. These can promote improved water quality by guiding the growth of a community away from sensitive areas and by restricting certain types of growth to areas that would be able to support it without compromising water quality. Site-based local controls include preservation of buffer strips and riparian zones (areas directly contiguous to a stream or river, i.e. banks and some extension thereof), minimization of disturbance and imperviousness, and maximization of open space.[34]

BMP's may also be structural or physical, not just policy oriented. Some examples of structural BMP's can be categorized into infiltration practices and vegetative practices. Infiltration practices facilitate percolation of stormwater into the soil and/or reduce amount of runoff and include porous pavement and dry wells that hold stormwater after a rain event. Vegetative practices enhance pollutant removal, maintain natural site hydrology, and promote healthier habitats. They include vegetated swales, filter strips, and rain gardens.[35]

The NPDES Phase II Rule states that the stormwater management program of a small MS4 community must "develop and implement strategies which include a combination of

[33] "Storm Water Phase II Final Rule: Post-Construction Runoff Control Minimum Control Measure". United States Environmental Protection Agency, Office of Water, Washington, DC. January 2000, Fact Sheet 2.7, p. 2.
[34] Ibid, 10.
[35] Ibid, 2.

structural and/or non-structural BMP’s.” BSD is a method of developing land that qualifies as one such strategy.

CHAPTER 4
SCIENCE SUPPORTING BETTER SITE DESIGN

It has already been noted that BSD seeks to reduce impervious cover and maintain vegetation on site, both in quantity and maturity. This section will offer case studies that demonstrate BSD does indeed reduce impervious cover and supports the maintenance of vegetation on development sites. This information will be followed by the negative implications of impervious cover in urban areas detailing several facets. These are hydrologic impacts, physical impacts, water quality impacts, and biological impacts to urban streams. Finally, explication of the benefits of urban forests/vegetation as they relate to local water quality will be supplied.

4.1 Case Studies

Several case studies demonstrate the benefits of BSD. This section provides comparative analyses of a residential development and a commercial development using conventional design standards versus the same developments using BSD techniques. Actual residential and commercial sites constructed in the 1990's using the conventional standards are compared to the same sites "redesigned" using BSD techniques. The analysis utilizes a computer model to compare the sites. The Simplified Urban Nutrient Output Model (SUNOM) was used to perform these analyses.

A medium density subdivision known as Stonehill Estates was used for the residential comparison. SUNOM was used to compare five different development scenarios: (1) Pre-developed conditions, (2) Conventional design without stormwater practices, (3) Conventional design with stormwater practices, (4) Open space design without stormwater practices, and (5) Open space design with stormwater practices. A comparison of the hydrology, nutrient export, and development cost for this site is demonstrated.

Stonehill Estates is located near Fredericksburg, VA, and the undeveloped parcel was 45 acres in size. The parcel consisted mainly of hardwood forest. A natural wet weather conveyance runs through the site and discharges into a stream. Approximately 3.6 acres of wetlands were found along the stream corridors, and an extensive floodplain was located along the larger stream. Soils on the site were moderately permeable as far as soils go.[36]

The conventional design was zoned for three dwelling units per acre. The parcel yielded 108 house lots after unbuildable areas were excluded, each being approximately 9,000 square feet in size. Lot sizes were essentially unified in shape and size. The design incorporated wide and moderate streets and six large diameter cul-de-sacs for turnarounds. Sidewalks were installed on both sides of the street. Street runoff was conveyed by curbs and gutters into a storm drain system that discharged runoff into an intermittent (wet weather) stream channel that flowed into a detention pond. Notably, the conventional design did reserve 25% of the land as open space. However, this space was essentially unbuildable because of floodplains, steep slopes, wetlands, and stormwater facilities. Also, the open space was highly fragmented. Further, the wetlands were impacted by two road crossings, and about 90% of the original forest was cleared for lawns and impervious cover, of which 60% became lawns and 27% became impervious cover.[37]

The redesign utilized many of the open space design techniques advocated by Randal Arendt (open space design pioneer), resulting in the same number of lots but with a much different layout. The lot size was reduced to 6,300 square feet allowing 44% of the site to be used as open space. Narrower streets, shorter driveways, fewer sidewalks, and loop roads in place of cul-de-sacs were incorporated. Each individual lot was located adjacent to open space so the more compact lots would not seem so “crowded.” As a result, impervious cover declined by 7% and lawn cover declined by 30%. The stormwater

[36] “The Benefits of Better Site Design in Residential Subdivisions.” Article 46, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 638.
[37] Ibid.

system utilized dry swales rather than storm drains in the more gently sloping areas of the site. Also, bio-retention areas in the loop roads were used to treat runoff.[38]

The pre-developed site produced a minimal amount of surface runoff, but because of tight soils, generated a small amount of infiltration. This could be attributed to the presence of a significant amount of mature trees. Table 4.1 shows the comparative hydrology of the two design approaches and pre-development conditions. Surface runoff increased by a factor of five in the conventional design, and infiltration was reduced by about 40%.

While the conversion of the forest into a conventional subdivision increased the nutrient export from the site, the computer model indicated that phosphorus and nitrogen export would increase by a factor of 7 and 9, respectively, in these type developments. The model also indicated that stormwater runoff contributed almost 94% of the annual nutrient export from the site. In contrast, the open space design resulted in greater nutrient export reduction. For example, annual phosphorus export in this type of design was 22 pounds per year, according to the simulation, whereas in the conventional design it was 28 pounds per year. Correspondingly, the annual nitrogen export in the BSD design was 186 pounds per year and 236 pounds per year in the conventional design.[39]

Finally, although not an emphatic element of this paper, infrastructure costs were incorporated into the analysis, and this aspect offers another level of encouragement to incorporate such techniques. The total cost for infrastructure in the open space design was approximately 20% less than the conventional design. Less road paving, shorter sidewalks, curbs and gutters, and water and sewer lines all contributed to this cost reduction. It was estimated that the cost for the conventional design was $1.54 million while the cost for the development utilizing the open space design was $1.24 million.[40]

It is only appropriate that a commercial development comparison be incorporated as a

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[38] "The Benefits of Better Site Design in Residential Subdivisions." Article 46, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 640.
[39] Ibid, 641.
[40] Ibid.

Table 4.1 Comparative Hydrology of Stonehill Estates[41]

	Pre-developed	Conventional Design	Open Space Design
Runoff (inches/year)	2.1	10.6	8.8
Infiltration (inches/year)	4.9	3.1	4.0

means of reinforcement. In this example, focus is on reduction of area and use of alternate surfaces on a parking lot. The test site is the Old Farm shopping center in Frederick, MD. Pre-development, this site was primarily meadow with some shrubby forest.

The size of the parcel is 9.3 acres and contains a typical suburban shopping strip mall. The center devoted 50% of its total area to parking in the original design with 16% of the total area as actual building footprint. 24% of the site was devoted to landscaping/stormwater treatment, and less than 10% of its natural cover remained (the entire site was almost completely cleared for development). The parking lot design provided 5.2 full-size stalls per 1,000 square feet of retail space, which was in excess of the already generous local requirements.[42]

The stormwater treatment system consisted of an infiltration basin near the rear of the shopping center that captured runoff from about one third of the site. Also there were 3 oil grit separators that provided some treatment for the remaining area of the site. It should be noted, however, that oil grit separators have little or no pollutant removal capability according to recent performance monitoring.[43]

The site was redesigned maintaining the same retail space but with a different layout

[41] "The Benefits of Better Site Design in Residential Subdivisions." Article 46, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 640.
[42] "The Benefits of Better Site Design in Commercial Development." Article 47, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 648.
[43] Ibid.

altogether. The area devoted to parking was significantly reduced to 38% of the total area of the parcel. This was accomplished by reducing the demand ratio from 5.2 spaces per 1,000 square feet of retail area to the more appropriate ratio of 4.4 spaces per 1,000 square feet of retail space.[44] According to the most recent national parking research, only 4.0 to 4.5 spaces are needed to serve shopping centers.[45]

No extra parking spaces were allowed beyond the requirements of the municipality and the demand ration was reduced by about 15% to more accurately reflect actual demand. The total number of spaces dropped from 343 to 291. Also, 17% of the stalls were designed for compact cars further reducing the lot size by over one acre in all. This reduction in lot size allowed room for more adequate landscaping and stormwater treatment opportunities.[46]

Several of the parking lot islands were increased in size and converted to bio-retention areas. Also included in the system were a sand filter, infiltration trench, and a filter strip. Further, 25% of the entire parking area was designated as spillover/overflow parking area. Grid-pavers were used to pave this area, which help store the first few tenths of an inch of rain that would otherwise runoff of the parking lot. Finally, the redesign enabled greater protection and reforestation of the buffer along the adjacent stream, resulting in the proportion of natural cover on the site to increase from 7% to 19%.[47]

The original construction of the shopping center significantly changed the hydrology of the site. Impervious cover increased from 1% to 70% and increased the annual runoff volume by a factor of nine. Conversely, the new design produced 20% less runoff than did the original. This information can be found in table 4.2. Additionally, the nutrient export from the site was greatly increased with the conventional development. The model indicated that annual phosphorous and nitrogen export would increase tenfold as

[44] "The Benefits of Better Site Design in Commercial Development." Article 47, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 648.
[45] Ibid, 649.
[46] Ibid, 650.
[47] Ibid.

Table 4.2 Comparative Hydrology of the Old Farm Shopping Center[48]

	Pre-developed	Conventional Design	Innovative Design
Runoff (inches/year)	2.6	18.1	15.1
Infiltration (inches/year)	11.8	8.9	9.1

result of the development. SUNOM indicated that 95% of the annual nutrient export was attributed to stormwater runoff. The combination of the redesign and addition of stormwater treatment practices reduced the total nutrient export by 50% of the conventional design.[49]

Here again, cost was reduced when the redesign was applied. Although cost reduction was not as significant as the residential example, it was nevertheless reduced by 5% according to the SUNOM model. The conventional parking lot cost $782,500 to build, while the cost of the redesigned lot was $746,270.

4.2 Impacts of Impervious Cover on Proximal Streams

As you already know, urbanization has many negative implications when it comes to surface water quality. Even further, there is no evidence that urban development increases water quality in any way, even using friendlier techniques such as BSD. The primary cause of proximal surface water quality deterioration is the introduction of mass amounts of impervious cover associated with urbanization. This cover appears in the form of streets, driveways, sidewalks, parking lots, and rooftops, among others. This section provides detail on exactly how impervious cover impacts nearby streams. The affects are classified into four categories: changes in hydrologic functions, physical characteristics, decreased water quality, and detriment of biological indicators. It should be noted that the hydrologic change is the driver for water quality impairment.

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[48] "The Benefits of Better Site Design in Commercial Development." Article 47, Watershed Protection Techniques. Center for Watershed Protection, Ellicott City, MD. p. 650.

[49] Ibid.

Hydrology

Hydrology is defined as the study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, and on or below the land surface.[50] For our purposes we will focus on the effects of precipitation upon the occurrence and character of water in streams.

Impervious cover is a surface that cannot be infiltrated by water, in this case stormwater. This cover decreases infiltration rates, increases runoff velocities, and subsequently the efficiency at which runoff is delivered to streams. Schueler, a pioneer in impervious cover research demonstrated that runoff values are directly related to watershed impervious cover. Figure 4.1 visualizes his findings. The runoff data was derived from 44 small catchment areas across the country for EPA's Nationwide Urban Runoff Program (NURP). To further illustrate the point, Table 4.3 offers data portraying the difference in runoff volume between a meadow and a parking lot, as compiled from engineering models. The parking lot produces more than 15 times more runoff than a meadow for the same storm event.[51]

This increase in runoff could be considered to have a direct effect on peak discharge rate. Peak discharge rate is simply defined as the velocity of discharge when stream flow is greatest after a storm event. If this rate is increased after development, more runoff is entering the stream. This rate has a strong influence on magnitude and frequency of flooding, which directly alters habitat among other things.[52]

Correspondingly, urbanization increases the frequency and duration of peak discharge associated with smaller flood events. These more frequent "bankfull" flows are actually much more important than large flood events in terms of forming the channel. This

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[50] www.weather.com. 26 February 2004, 8:25 AM.

[51] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 27.

[52] Ibid, 30.

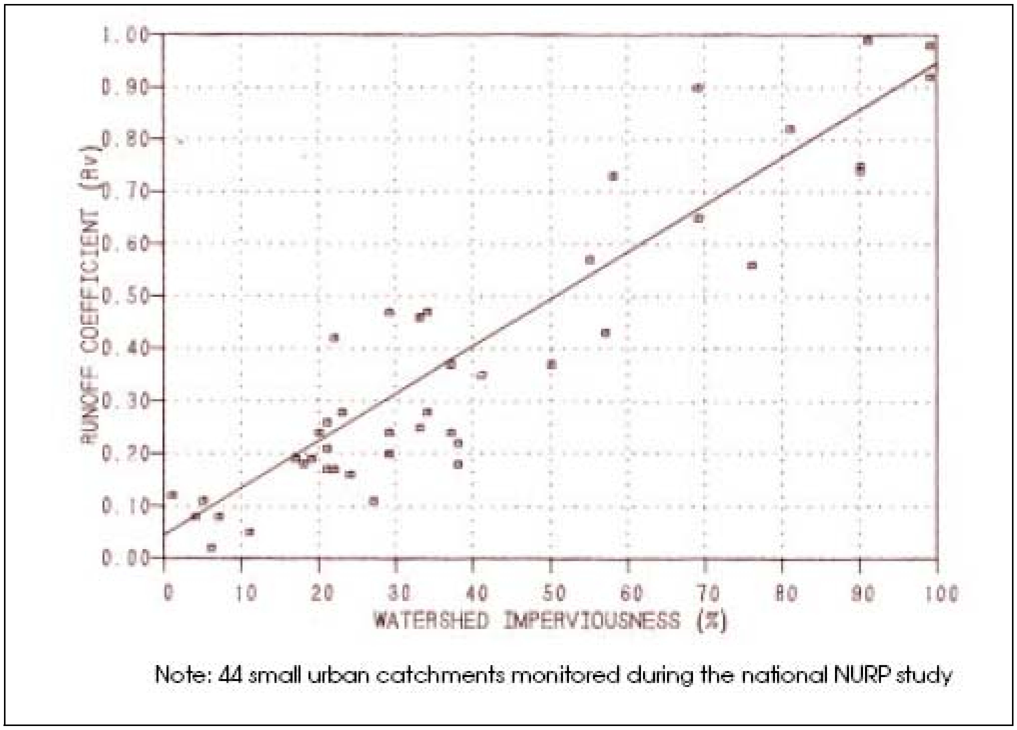

Figure 4.1 Runoff Coefficient vs. Impervious Cover[53]

[53] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 27

Table 4.3 Hydrologic Differences Between a Parking Lot and a Meadow[54]

Hydrologic or Water Quality Parameter	Parking Lot	Meadow
Runoff Coefficient	0.95	0.06
Time of Concentration (minutes)	4.8	14.4
Peak Discharge, two-year, 24 hr. storm (cfs)	4.3	0.4
Peak Discharge Rate, 100-year storm (cfs)	12.6	3.1
Runoff Volume from one-inch storm (cu. ft.)	3450	218
Runoff Velocity @ two-year storm (ft./sec.)	8	1.8
Assumptions: 2-yr., 24-hr. storm = 3.1 in.; 100-yr. storm = 8.9 in. *Parking lot*: 100% imperviousness; 3% slope; 200 ft. flow length; hydraulic radius = .03; concrete channel; suburban Washington 'C' values *Meadow*: 1% impervious; 3% slope; 200 ft. flow length; good vegetative condition; B soils; earthen channel		

[54] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 29.

stream morphology is directly connected to ecological associations.[55]

Physical Characteristics

As evidenced, impervious cover alters the hydrology of a receiving stream. This alteration has negative implications in regards to stream habitat. These implications are a result of changes occurring to the physical nature of the stream. Here, changes in stream geometry as a result of urbanization and their effects on individual elements of stream habitat will be provided. This will be followed by evidence of stream warming as a result of urbanization.

As noted in the previous section, urbanization causes an increase in the frequency and duration of bankfull flow events in streams. The events have a more pronounced effect on the stream channel than flows that occurred at a lower frequency and duration. In other words, the channel is exposed to more stress above the critical threshold needed to move bank and bed sediments than otherwise would be. This may activate bank erosion and greater downstream sediment transport. The stream channel reacts to these occurrences by expanding its cross-section in order to accommodate these greater flows and sediment loads. The channel may be enlarged through the cutting of its banks or the scouring of its bed. Figure 4.2 illustrates channel enlargement as a result of impervious cover.

Increased flow, bank erosion, and sediment loads have numerous implications on habitat. Individual habitat features such as bank stability, embeddedness, riffle and pool quality, and presence of large woody debris are all affected.

A study by Booth in the streams of the Puget Sound lowlands showed that stream banks were consistently rated as stable in watersheds with less than 10% impervious cover, and

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[55] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 31.

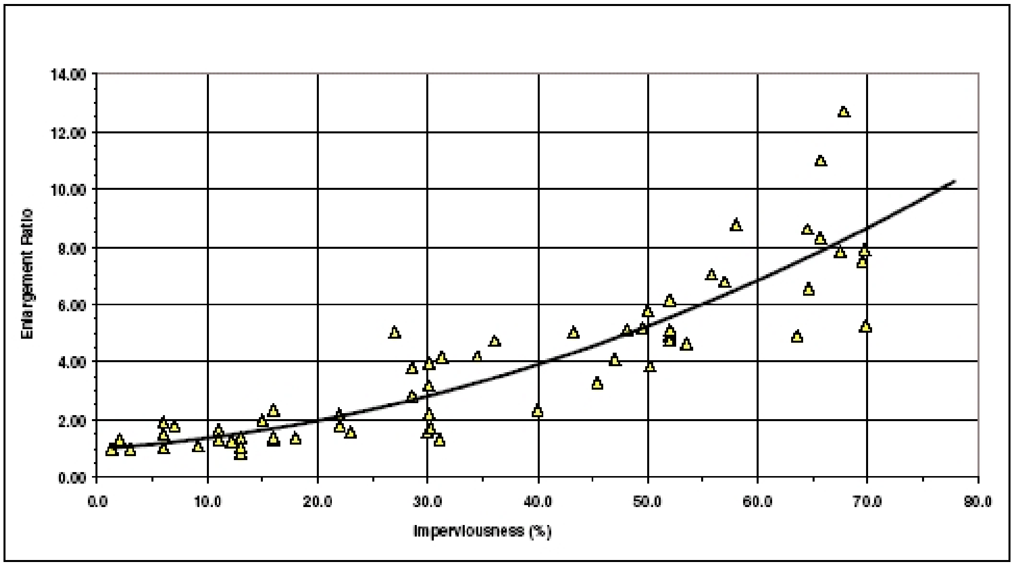

Figure 4.2 Ultimate Channel Enlargement in MD, UT, and TX Alluvial Streams[56]

becoming more unstable above this threshold.[57]

Embeddedness is defined as the extent to which the spaces between rocks in a stream bed are filled with sediment, which may include sand, clays, and silts. The lack of fine sediments in these spaces would indicate overall health in a stream. These areas are active habitat zones and detrital (organic matter) processing areas. The increased sediment loads due to bank cutting and bed scouring are direct sources of increased embeddedness. Riffles, areas in a stream where the surface of the water appears rough or choppy due to the grooves between the rocks, are an important habitat for aquatic insects and fish.[58]

"Large wood debris (LWD) is a habitat element that describes the approximate volume of large woody material (<4 inches in diameter) found in contact with the stream." The presence of this material, along with its stability is an important parameter in stream

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[56] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 45.
[57] Ibid, 47.
[58] Ibid.

health. In significant amounts, LWD serves to create dams which form pools, trap sediment and detritus, stabilize the stream channel, dissipate flow energy, and promote habitat complexity. Due to increased flow from impervious cover, urban streams have a decreased supply of LWD—it is moved downstream.[59]

Finally, impervious cover has a direct effect on increased stream warming. Impervious areas can easily heat up to extreme temperatures, especially those are black in color. These areas absorb solar energy and release it very slowly. As water flows over these surfaces, its temperature increases correspondingly. This water then flows into urban streams, where its effects are obvious. Summer temperatures in urban streams have been shown to increase by as much as 12 degrees F in response to watershed development. These increased water temperatures make it impossible for temperature-sensitive species to survive. In 1990, Galli reported on a study that included information from 5 different streams in the Maryland Piedmont. He showed that stream temperatures throughout the summer increased in urbanized areas. Each stream studied had average temperatures that were consistently warmer than a forested reference stream, and was directly caused by impervious cover (Figure 4.3).[60]

Water Quality

When pollutants are deposited onto impervious cover, they have no chance of percolating into the soil and allowing nature to provide its ability to "handle" these pollutants. Instead, they remain on the surface waiting for a storm to produce the water needed to wash them off. Upon a storm event, these pollutants load the runoff and are eventually discharged into nearby waters. This section offers information on pollutant concentrations found in urban stormwater runoff based on national and regional data assessments. Additionally, specific water quality impacts of these pollutants along with their sources are provided.

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[59] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 49.
[60] Ibid, 50.

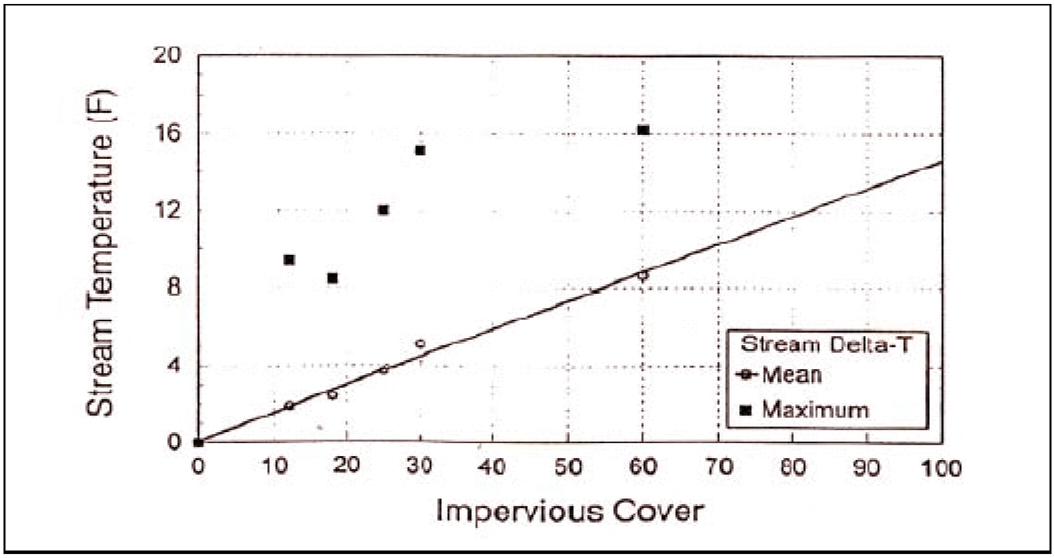

Figure 4.3 Stream Temperature Increase in Response to Impervious Cover in Maryland Piedmont Streams[61]

These pollutants are categorized into 9 broad groups: sediment, nutrients (phosphorous and nitrogen), metals, hydrocarbons, bacteria and pathogens, organic carbon, Methyl Tertiary-Butyl Ether (MTBE) (gasoline additive used to increase the efficiency of combustion engines), pesticides, and deicers. The impact these pollutants have depend on their concentrations, annual loads, and category. The annual load can have long-term effects on stream water quality. Different pollutants have different implications: sediments affect habitat and aquatic biodiversity; nutrients cause eutrophication; metals, hydrocarbons, deicers, and MTBE are toxic to aquatic life; and organic carbon can lower dissolved oxygen levels. Bacteria and pathogens have a direct relationship with human health. This affects people's interaction with the water, including the ability from which to obtain food, recreational pursuits, and drinking water.[62]

The unit area pollutant load delivered to receiving waters by stormwater runoff increases in direct proportion to watershed impervious cover. Given that runoff volume increases

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[61] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 50.
[62] Ibid, 55-56.

in direct proportion to impervious cover, pollutant loads must also increase given a sustained amount of pollution concentration. This fact is the basis for the notion that increased impervious cover negatively affects local water quality. Recognizing this relationship, Schueler developed the "Simple Method" to estimate stormwater pollutant loads for small urban watersheds. The Simple Method is empirical and uses the national database for its operation, which includes data from NURP, the U.S. Geological Survey, and initial stormwater monitoring conducted for the NPDES program.[63]

Sediment can be measured in three ways: Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and turbidity. TDS is a measure of the dissolved solids and minerals present in stormwater runoff and is used as an indicator for the purity of drinking water. TSS is a measure of the total mass of suspended sediment particles in water. And turbidity is a measure of how suspended solids in water reduce the ability of light to penetrate the water column, allowing/disallowing aquatic plants to receive light for functions and affecting the ability of aquatic life to use their gills.[64]

Deposited sediment can smother benthic organisms and freshwater mussels. Stream warming may occur due to increased turbidity which reflects radiant energy. Flow capacity may be decreased and overbank flows increased. Further, sediments transport other pollutants such as trace metals and nutrients. The primary source of these sediments is from stream banks themselves as a result of increased flow due to impervious cover. Additional sources are erosion from construction sites, and wash-off from impervious areas.[65]

Nutrients are another source of pollution to urban streams. While nitrogen and phosphorous are essential for aquatic systems, they can be harmful at higher concentrations. As already established, impervious cover increases the amount of runoff

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[63] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 61.
[64] Ibid, 63.
[65] Ibid, 64.

that is discharged to streams. An increased amount of runoff will carry an increased amount of pollution, which is in turn deposited into streams. While increased concentrations of phosphorous and nitrogen are known to be detrimental to streams, the focus of study on the impacts of these nutrients is on downstream receiving waters such as lakes and larger rivers. An influx of these nutrients can cause eutrophication, which is a condition that is experienced by slow to non-moving water bodies whereby the nutrients cause an increase in algal blooms and growth. As these blooms die and decay, bacteria break them down and deplete available dissolved oxygen, depriving it from other aquatic life. Often phosphorous particles attach to sediment particles which are then washed off into a stream. Nitrogen is normally transported by runoff in soluble form. Sources of these nutrients include fertilizer, pet wastes, organic matter, and erosion. Also, atmospheric deposition is a major contributor.[66]

Trace metals are another pollutant found in many urban streams at potentially harmful concentrations. Examples include zinc, copper, lead, cadmium, and chromium. The sources of these pollutants are automobiles, weathering of other metals and paints, burning of fossil fuels, and atmospheric deposition. The primary concern about metals in streams is their toxicity to aquatic organisms. High concentrations may lead to bioaccumulation (accumulation in the tissues and organs) of metals in plants and animals, acute toxicity, and contamination of sediments which could affect bottom dwelling organisms.[67]

Yet another pollutant category found in urban streams is hydrocarbons which include oil and grease. Hydrocarbons typically are attached to sediments and often end up at the bottom of receiving waters such as lakes. Like trace metals, the primary concern is the toxicity to aquatic organisms in the form of bioaccumulation and acute toxicity. Hotspots

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[66] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 68-70.
[67] Ibid, 71-72.

as sources for hydrocarbons are gas stations, commuter parking lots, convenience stores, and residential parking areas and streets.[68]

Of direct importance and concern to human welfare are bacteria and pathogens. One specific bacterium of concern is coliform, which is typically found in the digestive tract of warm blooded animals. The coliform family consists of fecal coliform, fecal streptococci, and e-coli, which are consistently found in stormwater runoff. The presence of these bacteria indicates the presence of sewage in the water and other viruses and pathogens may be present.[69]

A pathogen is a microbe that is actually known to cause disease under the appropriate conditions. Two common water borne pathogens are Cryptospiridium and Giardia. Both cause intestinal problems. Young and Thackston showed that bacteria concentrations at four sites in metro Nashville were directly related to watershed impervious cover. Increasing impervious cover reflects the cumulative increase in potential bacteria sources such as sewage overflows, failing septic systems, and inappropriate discharges.[70]

The remaining pollutants are transmitted to urban streams in the same manner as the foregoing ones—in urban stormwater runoff. Increased imperviousness alters the hydrology of a watershed such that more water is discharged to streams than would be if it had the opportunity for infiltration. Pollution increases with urbanization and population growth in an area. Combined with increased runoff, the effects to urban streams can be very detrimental.

Biological Impacts

While some mention has been made of possible impacts of impervious cover on aquatic life, this section provides more detail on the topic. The focus is on aquatic insects, fish,

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[68] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 75-76.
[69] Ibid, 77.
[70] Ibid, 77-78.

and freshwater mussels. The previous information has laid a foundation for this section.

Ecologically, biological diversity, also known as biodiversity, is often used as an indicator of ecosystem health. Further, aquatic insect biodiversity in a stream is often used as an indicator for the health of that stream. This is primarily due to the fact that aquatic insects form the bottom link in the food chain in a stream. Declines in insect biodiversity are usually indicative of further reaching biological problems and impacts due to watershed development. Response to urbanization appears in the form of diversity decline in favor of those species that are more pollution tolerant.[71]

Klein noted that aquatic insect diversity drops sharply where impervious cover in the watershed exceeded 10 to 15%. "Good" to "fair" diversity was recorded in watersheds with less than 10% impervious cover, and "poor" diversity was indicated where watershed impervious cover was 12% or more. It is abundantly clear that urban streams in a watershed with greater than 25% impervious cover are essentially unable to support diverse aquatic insect communities. In undisturbed streams, aquatic insects use specialized feeding mechanisms such as shredding leaf parts, filtering and collecting floating organic matter, or eating other insects. These are replaced by grazers, collectors, and deposit feeders in impacted streams. One study showed that 90% of sensitive species were eliminated from the aquatic insect community when impervious cover was greater than 10 to 15% in certain Delaware watersheds.[72]

Fish diversity is also impacted by urbanization and imposing impervious cover. Obviously, fish communities will be affected if their food source(s) is affected. But other contributors to fish community impacts exist. Sensitive fish depend on clean and stable bottom substrates for feeding and breeding. The loss of these sensitive species and their subsequent replacement by pollution-tolerant ones are indicators of declining stream health. A study conducted in the Maryland Piedmont showed that, as the level of

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[71] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 100.
[72] Ibid, 100,103.

imperviousness in the watershed increased, the number of fish species collected dropped. Two sensitive species were lost when impervious cover increased from 10 to 12% and four more species were lost when imperviousness reached 25%. Of note, only two species remained when the watershed reached 55% impervious cover.[73]

Being filter feeders and usually sessile (attached to substrate), freshwater mussels are viable indicators of stream health. 725 freshwater mussel species in the U.S. are considered endangered, threatened, or of special concern. The primary reasons cited for this are sedimentation and modification of aquatic habitats. Sediment deposition can smother mussels. If this sedimentation isn't fatal to the mussels, it can interfere with feeding and its metabolic processes. Bauer did a study that showed the major sources of mortality to mussels to be impoundment of rivers and streams and eutrophication. Further, freshwater mussels are hypersensitive to heavy metals and pesticides. Certain compounds are known to inhibit respiratory efficiency and lend to bioaccumulation effects.[74]

4.3 Benefits of Urban Trees

BSD calls for retention of open space and some mature vegetation on the development site. This open space may consist of turf or it could be left in its natural state with groves of large trees possibly comprising a forest situation. Either way, the cover will not be impervious. The purpose of this section is to provide the benefits that urban trees provide in terms of stormwater runoff, including erosion prevention and reduction of runoff quantity.

First and foremost, trees and other vegetation protect the soils from erosion and increased stream sedimentation. Roots hold the soil structure together and fallen leaves protect the surface of the ground from the impact of raindrops. Also, the living foliage of trees and

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[73] Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott City, MD. March 2003. p. 107.
[74] Ibid, 115.

other vegetation can absorb the force of the raindrop so as to protect the soil from being dislodged and transmitted to a nearby stream.

Erosion prevention is a crucial function of trees in protection of urban surface water quality, but they have a function that is fantastically beneficial in terms of reduction of stormwater runoff. It has been noted that trees have the ability to retain water on site, some permanently and some temporarily, but always slowing the flow of runoff to waterways. Healthy trees can reduce the amount of runoff and consequently pollutants entering nearby streams in two ways: (1) Leaves, branch surfaces, and trunk bark intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows and (2) Root growth and decomposition increase the capacity and rate of infiltration by stormwater and reduce overland flow.[75]

During a rainfall event, precipitation is intercepted by leaves, branches, and the main stem, slowing its journey to ground and at the same allowing for greater evaporation. Retainment is influenced by three factors: character and magnitude of the storm event; tree species, structure, and age; and weather. Trees retain more water during a 1-inch rainfall event that lasts two days than one that lasts only two hours. Structure, leaf, and bark surface area differ by species and each one controls the storage of rainwater in its own unique way. Temperature, relative humidity, net radiation, and wind speed all control the length of time rainfall is retained in storage. However, it is true that planting more trees and improving the health of and maintaining stands of existing trees will help reduce the volume of stormwater runoff. A study showed that one large tree in southern coastal California reduces stormwater runoff by 4,000 gallons per year, and a typical community forest of 10,000 trees will retain approximately 10 million gallons of rain water per year.[76]

"Tree rainfall interception plays an important role in the urban ecosystem. It affects all

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[75] Summary of "Rainfall Interception by Sacramento's Urban Forest." Xiao, Q.F., et al, 1998. Center for Urban Forest Research, Davis, CA. 2003.

[76] Ibid.

hydrologic processes as well as the spatial and temporal redistribution of moisture. In the urban ecosystem, canopy rainfall interception changes the urban runoff process by reducing the flow rate and shifting the runoff concentration time via temporal water storage on the canopy surface."[77]

Trees with relatively large crown and leaf surface areas provide significant storage capacity for rainwater. During rain events, each tree functions like a mini-reservoir, controlling runoff on site. Rainfall interception by the entire urban forest can be estimated through linear theory by summing the contributions of each individual tree.[78]

This particular study uses computer simulation to quantify rainfall interception by public trees in Santa Monica, CA. A single-tree rainfall interception model was used to estimate rainfall interception by different tree species at different growth stages. The model accounts for rain intercepted by the leaf and stem surfaces. Tree surface water storage, throughfall, stem flow, and evaporation were simulated at 1-hour time intervals.[79] Inventory data was limited to 29,229 public trees, of which were 87% street trees and 13% park trees.[80] Rainfall interception by public trees was presented at three temporal scales: annual, 25-year flood event, and single event.[81]

Total annual rainfall interception was 191,168 cubic meters. For the 25-year flood event, total precipitation was 134.2 mm, of which 7.3% was intercepted at the tree crown level and 0.4% at the landscape level. Runoff reduction was 12,159 cubic meters.[82] It was precipitation (6.6 cubic meters of water per tree).[83]

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[77] Xiao, Q. "Rainfall Interception by Santa Monica's Municipal Urban Forest." Urban Ecosystems, 6:291-302. 2002. p. 291.
[78] Ibid, 292.
[79] Xiao, Q. "Rainfall Interception by Santa Monica's Municipal Urban Forest." Urban Ecosystems, 6:291-302. 2002. p. 293.
[80] Ibid, 294.
[81] Ibid, 295.
[82] Ibid, 296.
[83] Ibid, 301.

CHAPTER 5
SURVEY METHODOLOGY AND RESULTS

In an effort to encourage local land developers (and possibly planners) to apply BSD techniques, a "Visual Preference Survey" was developed to compared certain conventional development techniques with comparable BSD techniques. It was then implemented on the World Wide Web (Appendix). This survey is the basis of the thesis; with the expectation that the majority of people would have a visual preference for developments utilizing BSD techniques over the conventional ones. Consequently, one could deduce that these same people would be more willing to purchase a home in a development/community that applied such techniques, given that the cost and/or levels of maintenance were not outrageously exorbitant compared to the conventional techniques (which they are not). This chapter explains the methodology behind the survey including how it was administered, who the sample consisted of, and its limitations. Further, each "scenario" will be extracted from the survey and presented with the model development principle to which it applies. Results of the survey will be supplied with each scenario and supplemented by holistic results.

5.1 Methodology

As previously stated, the survey instrument utilized a "Visual Preference" methodology in which two graphical images were presented and the respondent was asked to choose which image he preferred in terms of aesthetics. One image consisted of a BSD technique and the other of a conventional technique. Each comparison will be referred to as a "scenario" throughout the duration of the paper, and there were 12 different scenarios in all. The "Visual Preference" section was followed by a demographic questionnaire in order to gain some insight on the respondents themselves. The answers were scored as either supportive or non-supportive of the hypothesis, the "supportive" choices being the BSD techniques. The answers were stored in a database throughout the active term of the survey awaiting analysis using the Statistical Package for Social

Science (SPSS) software. The survey was initiated on 27 January 2004 and terminated on 3 March 2004. The survey was web-based, and placed on an active internet link that was attached to a server owned by the University of Tennessee. The survey could be accessed only by using this link. The Visual Preference section consisted of 12 scenarios consisting of two images per scenario. Preference was indicated by clicking on the "radio button" under the appropriate image. Once the choice was made the next page/scenario could be accessed by clicking the "Next Page" button at the bottom of the page. The demographic questionnaire consisted of questions whereby the respondent could choose one of several answers provided or by filling in a blank (open-ended). Upon completion of the survey, respondents were asked to click on the "Send Answers" button, at which point the responses were immediately sent to the database.

The sample consisted of Tennessee residents only, and could be considered a "networked" sample of convenience. Upon accessing the survey, a respondent was asked if he were a resident of the state of Tennessee. If the answer was no the responses were thrown out. The sample was acquired through several means. First, information regarding the survey and its link was incorporated into a paper flier. This flier was hung in several locations including churches, markets, and libraries in locales consisting of Knoxville, Nashville, Jackson, and Memphis, TN. Secondly, I initiated an email message requesting respondents to take the survey. The body of the message consisted of the survey link and also requested the message be forwarded on. In order to negate bias and/or responses directly connected to me, I asked everyone that received the original message to forego responding to the survey. The primary reason for the original message was to get the word out. I had no direct relationship with most of the people to whom the message was forwarded. Thirdly, the link and request for response was placed on several private websites at the request of different individuals including myself.

Limitations exist in the survey methodology. One has to do with the psychological interpretation of the images. For example, the element that makes the image more visually pleasing may be the fact that the picture was taken on a sunny day. Lighting and

color would have significant effects on perception. The element of the image that was to be the focus was captured in the title of each scenario so as to reduce this particular limitation and direct the respondent to the appropriate aspect of the image. Other factors regarding depiction such as date and time of day that the picture was taken and general aesthetic qualities of unrelated items in the image may alter a person's perception of the image holistically. Another limitation exists in the sample. The fact that I sent out an email message ties some of the respondents to me, albeit indirectly. Also, the sample is not representative of typical Tennessee residents. Education and income levels are higher than the average resident which could suggest an affinity for choosing BSD techniques. Finally, the survey being web-based restricted respondents to those that have access to computer and internet technology.

5.2 Comprehensive Results

The survey respondents demonstrate overwhelming agreement with the hypothesis that BSD techniques are more aesthetically pleasing than conventional ones. Rate of agreement statistics for individual scenarios have been presented in the previous section. The purpose of this section is to provide the additional information gathered through the survey in order to better understand the characteristics of the respondents and provide some insight for land developers in their decision making processes. This section will begin with general demographic information and conclude with holistic survey results.

There were 182 valid responses to the survey. Of note, the gender ratio of the respondents was fairly balanced, with 46.2% of respondents being male and 53.8% of respondents being female. Other descriptive statistics include ages for the respondents, which ranged from 16 to 74 years. Also, about 32% were single, 63% married, and only 5.6 % of respondents were divorced. Occupations for respondents included librarian, engineer, professor, sales representative, attorney, biologist, and banker, among many others.

Detailed statistical data presented below about the sample group reflects an appealing market group whose visual preferences supported the use of BSD techniques. In other words, these figures should serve to ameliorate hesitation in application of BSD techniques, in terms of people's preference. First, 75.6% of respondents currently own homes, which qualifies them as having a stake in property ownership, both now and in the future. Of this group, 37.2% have owned at least one home and 61.4% have owned 2 or more homes. This is a significant number given that their responses directly relate to qualities of property and their preference. In other words, this group is more likely to have a greater influence in the home ownership market than would a group of renters. Although the likelihood of purchasing property in the next 10 years was fairly balanced (Table 5.1), the percentage of those that were very unlikely to purchase property in this time frame was only 16.5%. Further, those that did not fall into the "unlikely" scale at all consisted of almost 71% of the respondents. Again this fact is significant, in that it would qualify this particular group of respondents as having an influence on future home purchasing markets. To further qualify this sample in terms of likelihood of property ownership are level of education and level of income. One could deduce that higher levels of one or both of these qualities might lead to a greater possibility of the possessor of that quality to be a homeowner and thereby influence the market. Survey statistics indicate that over 97% of all respondents had at least some college education, with almost half having a college degree and one third having a graduate degree. Additionally, over 75% of respondents had an annual income of at least $30,000, and over 40% making at least $50,000 annually.

Finally, all scenarios but 2 had a rate of agreement with my hypothesis that exceeded 90% (Table 5.2). The 2 scenarios that did not have this high of a rate still had an agreement rate of at least 63.7%. Three scenarios had an agreement rate of 98.9% with 3 others having an agreement rate above 96.7%. A chi-square test was implemented to show significance from a 50% response rate. The test showed a significant difference from a 50/50 break, which proves that responses in agreement that BSD techniques are

Table 5.1 Likeliness of Respondents to Purchase Property in the Next 10 Years

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Unlikely	30	16.5	16.5	16.5
	Unlikely	23	12.6	12.6	29.1
	Unsure	30	16.5	16.5	45.6
	Likely	47	25.8	25.8	71.4
	Very Likely	52	28.6	28.6	100.0
	Total	182	100.0	100.0	

Table 5.2 Counts and Percentages of Responses to Both Techniques

	Better Site Design		Conventional	
	Count	%	Count	%
Overflow Parking Area	180	98.9%	2	1.1%
Cul-de-Sac	179	98.9%	2	1.1%
Driveway	116	63.7%	66	36.3%
Parking Lot Island	172	94.5%	10	5.5%
Street	176	96.7%	6	3.3%
Vegetation on Lot	177	97.8%	4	2.2%
Subdivision Layout	162	90.5%	17	9.5%
Neighborhood Ditch/Culvert	175	96.2%	7	3.8%
Stream Bank	118	65.2%	63	34.8%
Commercial Ditch/Culvert	176	98.9%	2	1.1%
Stormwater Conveyance System	163	90.6%	17	9.4%
Sidewalk Design	176	97.8%	4	2.2%

more aesthetically pleasing are significantly more than 50% of the sample. Figure 5.1 is a graphical depiction of the percentage of respondents that found BSD techniques to be more aesthetically pleasing than conventional ones (the dashed line is the 50% mark).

5.2 Results by Scenario

The SPSS software enabled me to analyze specific elements of the survey. This section extrapolates each graphic scenario from the survey and correlates that particular scenario to the previously mentioned BSD model development principle to which it applies. After the images and corresponding model development principle are presented, survey results for that scenario will be provided. The scenarios will be provided in the order that they appeared in the actual survey. The model development principles as they are stated may not be fully represented by the corresponding graphics, however some element thereof will be depicted.

The first scenario consists of images comparing overflow parking areas in a commercial shopping center (Figure 5.2). The model development principle to which this scenario applies states: "Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas where possible." The "correct" answer in this scenario is the left graphic. This image shows the overflow parking area surface to be comprised of turf, which is very pervious to stormwater. The image on the right shows the conventional technique of continuation of pavement onto the overflow area. Analysis of the survey data demonstrated that 98.9% of respondents found the image on the left to be more visually pleasing.

The second scenario consists of images comparing cul-de-sacs in residential neighborhoods (Figure 5.3). The model development principle to which this scenario applies states: "Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles.

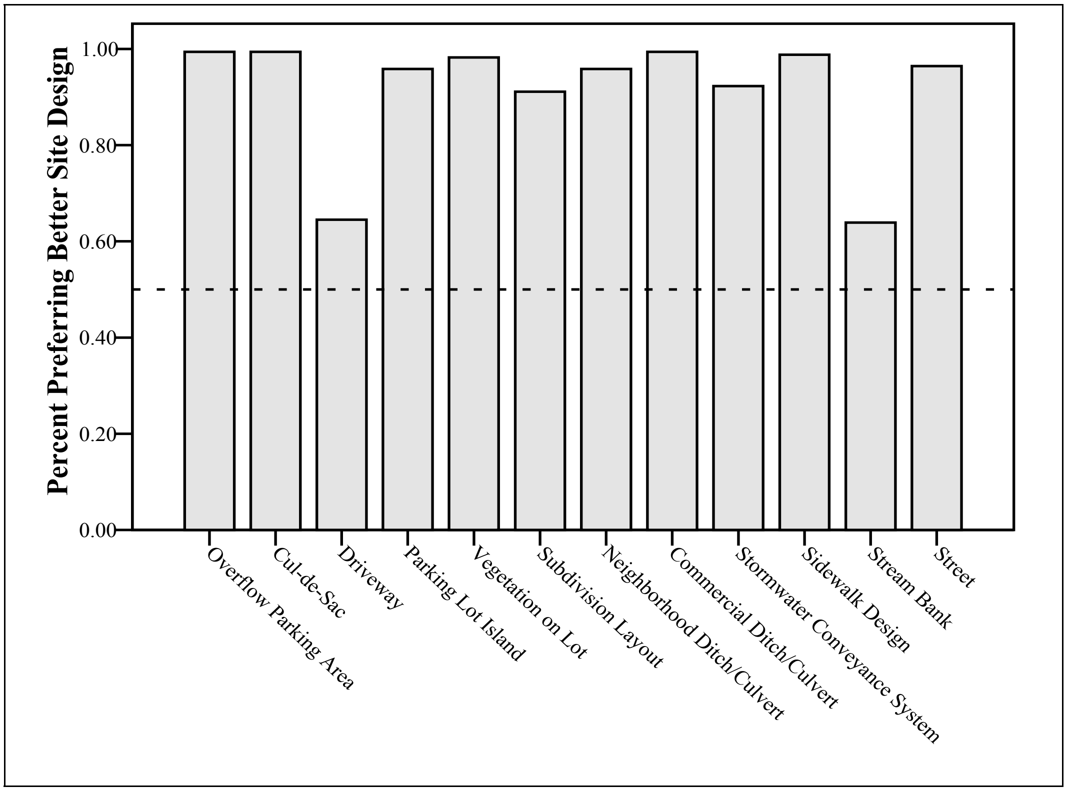

Figure 5.1 Graph of Percent Preferring BSD (by Scenario)

Figure 5.2 Graphical Comparison of Overflow Parking Areas

Figure 5.3 Graphical Comparison of Residential Cul-de-sacs

Alternative turnarounds should be considered." The "correct" answer in this scenario is the image on the right side. This image depicts a cul-de-sac that has a planted island in the center, which serves to increase stormwater runoff treatment opportunities. The left image is of the conventional approach, using asphalt to cover the entire cul-de-sac surface, whereby the entire surface is impervious. Analysis of the survey results found that 98.9% of the respondents were in agreement with the hypothesis that the planted cul-de-sac is more aesthetically appealing.

Figure 5.4 shows a comparison between driveways. The model development principle to which this scenario applies states:" Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together." The "correct" answer in this scenario is the left image. This image depicts a driveway that contains (2) elements of BSD. The first is the fact that the drive is split by turf, making it a two-track driveway. This turf is pervious to stormwater. Secondly, the driveway itself is made of pervious paving material. The image on the right is a conventional driveway made of asphalt which is impervious. Survey results show 63.7% of respondents to be in favor of the driveway in the left hand image. While this figure is not staggering, it nevertheless demonstrates a significant agreement with the hypothesis.

Figure 5.4 Graphical Comparison of Driveways

A comparison of parking lot islands is shown in Figure 5.5. The model development principle to which this scenario corresponds states:" Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands." The image that depicts an element of this principle is the one on the right. This image shows a parking lot island that contains an area for bioretention, treating stormwater runoff before it is discharged. The image on the left depicts a parking lot island that is continuous along the entire length of the lot and made of concrete, which is completely impervious. Analysis of the survey data shows 94.5% of the sample to find the BSD technique more visually pleasing.

Figure 5.6 compares two different residential street designs. The corresponding model development principle states:" Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume." The image that demonstrates this element is the one on the left. The actual

Figure 5.5 Graphical Comparison of Parking Lot Islands

Figure 5.6 Graphical Comparison of Residential Streets

pavement width is much narrower than conventional standards, and a grass strip separating the two travel lanes increases stormwater filtering opportunities as it runs off of the pavement. The image on the right shows an exorbitantly wide street completely paved. Analysis of the data in this scenario calculated 96.7% of all respondents to be in favor of the image on the left.

A comparison of vegetation on lots in residential areas is provided in Figure 5.7. Two model development principles could correspond to this scenario. They state: "Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner;" and "Conserve trees and vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas." The image on the right depicts a site where much of the pre-development vegetation was retained. Large mature trees exist in the front and back of the house. While most of the front is lawn, a cluster of mature trees and vegetation was kept. The picture on the left shows a site that was completely cleared of all vegetation before development. Further, minimal planting was done post-development. In fact, it is very difficult to see any new planting at all beyond the lawn. The photo on the left has two seedlings planted in the front yard. Given that I produced the photo, I can also attest that there were no trees at all planted in the backyard. In terms of visual preference, analysis of the survey data shows that 97.8% of those that responded to the survey found the lot with more vegetation on it to be more appealing

Figure 5.8 compares two subdivision layouts/designs. The image on the left is the BSD technique. The corresponding model development principle states: "Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection." The BSD design retains much

Figure 5.7 Graphical Comparison of Vegetation on Residential Lots

Figure 5.8 Graphical Comparison of Residential Subdivision Designs

mature vegetation, reduces road lengths, and preserves open space. The image on the right, while not as detrimental to water quality as other designs, nevertheless advocates long driveways, long road lengths, reduction in mature vegetation, and possibility of further subdivision in the future. No specific open space designation has been made. Further, the survey data analysis shows over 90% of the people that responded agreed that the BSD design was more visually appealing.

Figure 5.9 compares two approaches to conveying stormwater in a residential neighborhood. No specific model development principle applies to this scenario. However, the reduction of impervious surface in the left image remains consistent with ideals of BSD. Both channels were designed to convey stormwater runoff. The culvert on the right is made of concrete and offers no opportunity for infiltration or filtration of stormwater as it passes through. Further, it speeds the rate at which the runoff is conveyed. The culvert/conveyance on the left is naturally vegetated with grasses, offers significant opportunity for infiltration of stormwater, filters the runoff as it passes through, and slows the rate at which the water is conveyed, all to the benefit of surface water quality. Additionally, the survey data shows more than 96% of the

Figure 5.9 Graphical Comparison of Residential Culverts/Ditches

respondents to find the “green” ditch more attractive.

A visual comparison of two different stream bank scenarios is presented in Figure 5.10. The corresponding model development principle states: “The riparian buffer should be preserved or restored with native vegetation. The buffer system should be maintained through the plan review delineation, construction, and post-development stages.” The image on the left shows a stream bank that is denuded of all vegetation except grasses. While the image on the right is definitely not indicative of a true stream buffer, it employs certain features that certainly qualify it as more desirable in terms of water quality. First, it has mature trees that were left near the water that serve to stabilize the banks during high flows. There is other vegetation present as well that serve the same purpose. Also, the roots of these plants improve the structure of the soil in which they are growing. Also, the banks in the image on the right are stabilized with rip-rap, which are stones imbedded in the bank. This prevents erosion of the banks. While the BSD image on the right is not one of a riparian zone, its intent is to show that a site need not be entirely cleared to the water’s edge, and techniques can be applied that promote stream

Figure 5.10 Graphical Comparison of Stream Banks

health in some capacity. Data analysis shows 65.2% of the respondents to be in agreement with the hypothesis that the BSD technique is more attractive. Again, this number is not as overwhelming as most of the others have been. Even still, the group in agreement represents significantly more than have of the sample.

A comparison of two commercial culvert applications is shown in Figure 5.11. Here too, no specific model development principle applies, but the image on the left maintains ideals of BSD. It has a vegetated strip in the center of the ditch, reducing imperviousness and allowing enhanced infiltration and filtration opportunities before discharge. Also, the top of the bank is planted with shrubs which also filter runoff before it even enters the culvert. The image on the right is comprised of an all-concrete culvert, the implications of which have already been explained. Results of the survey are that almost 99% of the all respondents found the ditch with the grass strip in it to be more aesthetically appealing.

Figure 5.12 compares two approaches to residential stormwater conveyance from the road. The image on the right depicts a naturally vegetated open channel to convey stormwater runoff. The white "bar" to the right of the monkey grass and above the driveway is the top of the outlet structure that feeds this conveyance. The inlet structure

Figure 5.11 Graphical Comparison of Commercial Culverts/Ditches

Figure 5.12 Graphical Comparison of Residential Stormwater Conveyance Systems

exists on the lower side of the driveway, unseen in the image, and runoff flows underneath the driveway. The model development principle to which this comparison applies states: “Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.” The image on the left depicts the conventional curb and gutter approach, which provides no opportunity for infiltration or filtration, and quickly conveys the runoff to a nearby stream for discharge. Survey analysis shows over 90% of the sample to be in agreement with the hypothesis.

Finally, Figure 5.13 shows different approaches to sidewalk design. The corresponding model development principle states: “Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.” The image on the left shows a sidewalk that incorporates mature trees between the sidewalk and the street. This sidewalk is also much narrower than its counterpart, reducing the amount of impervious cover it provides. Finally, there is at least a strip of grass between this sidewalk and the street. Yet again, 97.8% of those that took the survey agreed that

Figure 5.13 Graphical Comparison of Residential Sidewalks

the BSD sidewalk was more attractive than the conventional one.

CHAPTER 6
CONCLUSION

Better Site Design (BSD) is an approach to land development that seeks to minimize the amount of impervious surface created and to retain a higher degree of more mature vegetation. Conventional land development techniques often create a large amount of unnecessary impervious surface with large parking lots, wide streets, and other applications. Also, the current trend in land development is to completely clear a site of all vegetation (including grasses) before development occurs. Finally, subdivision designs include those that have been in use for years and duplicated with slight variations to fit the site. Conventional design techniques have been proven to negatively affect nearby bodies of water that receive runoff from these developments, mainly due to the severe alteration of the natural hydrology of the area.

As evidenced in the Knox County Site Planning Roundtable, local developers are hesitant to apply BSD techniques for temporal and financial reasons. One primary reason is that their current designs and techniques seem to be selling at an acceptable rate, and a change to this approach might negatively affect revenues. The purpose of this thesis is to demonstrate that people might not only continue to purchase properties employing BSD techniques, but may even prefer to purchase these properties, finding BSD techniques more visually appealing than conventional ones. If a person lived in a community he found to be more visually attractive than one designed using conventional techniques, it can be inferred that his quality of life would be propelled to a higher status by living in that community (to what degree is unknown). It is my hope that the information presented herein will encourage developers to apply BSD techniques when they become incentivized, and not to despair when they become law.

The CWA was legislation designed to improve and maintain the health of our nation's surface waters. The cornerstone of the CWA is the NPDES program which was re-addressed in 1987. The NPDES program requires operators of MS4's to implement

strategies that seek to improve local water quality. One such strategy involves the element of post-construction runoff control. BSD, as an approach to land development, addresses post-construction runoff control directly.

BSD arose out of a national convention of concerned stakeholders. Model development principles were developed to explain what can be done to reduce impervious surfaces and maintain some natural vegetation in regards to land development. Further, it set out to guide communities in revising ordinances and implementing BSD techniques. The model development principles are categorized into streets and parking, lot development, and natural areas. Specific techniques that support water quality are offered under each heading, and include not only physical techniques but program and policy solutions as well. The Center for Watershed Protection stands as an authority on BSD and watershed protection education.

There have been several studies focusing on the topic of watershed imperviousness as it relates to water quality. Evidence suggests that watershed imperviousness is directly related to impaired water quality of the receiving body of water. Primarily, imperviousness alters the natural hydrology of the area, increasing not only the amount of water that runs off after a storm event, but the velocity at which it runs off. Stormwater does not have an opportunity to infiltrate the ground at the point where it falls, and it is not filtered at all as it runs across the ground's surface into a nearby body of water.

Increased flows and velocities increase the probability of erosion of soil in and around the stream itself. Its banks and bed may be scoured, depositing detrimental loads of sediment into the stream. Further, because there is no opportunity for infiltration and filtration, both of which act as stormwater "treatment," other pollutants are discharged into the stream at extremely higher rates. Other pollutants include oil and grease, nutrients, pathogens, and metals, all of which are harmful to aquatic life. Not only are the pollutants themselves prevented from entering the ground by an impervious surface, they are picked up by stormwater flowing into a stream (the soil acts as a natural buffer for

pollution, housing bacteria and other qualities that squelch the harmful effects of such pollutants present in manageable amounts). So if the amount of runoff entering a waterbody increases, the amount of pollution entering increases as well.

Urban pollution comes from fertilizers, vehicles, waste, and many other sources. This pollution can harm aquatic life which has innate benefits including ecological functioning, but also affects recreational and even economic opportunities. Further, this pollution can have a direct effect on human health through body contact of contaminated waters and especially if the water is used for drinking.

The corresponding survey presented 12 scenarios of land development techniques, especially as it relates to stormwater management. Each scenario consisted of a BSD technique and the comparable conventional one. Respondents were asked to choose which technique they found to be more aesthetically pleasing. An overwhelming percentage of the respondents found the BSD technique in every scenario to be more visually attractive than the conventional one. Although there were differences in perception due to the variation in image quality, colors, time of year and day (all of which were unintentional), these limitations seem to be insignificant given the statistics of the responses.

Respondents were not representative of the typical Tennessee citizen. The sample itself has a much higher level of education. However, income levels were not all too distant from the average TN homeowner, which supports the maintenance of the survey results. According to the US Census Bureau, 83% of Tennessee homeowners have an annual income of $20,000 or more. 86% of the survey respondents made at least $18,000 per year. 64.5% of Tennessee homeowners made at least $35,000 per year, where 75% of my respondents made at least $30,000 annually. Education data was not available for Tennessee homeowners, and it should be noted that no comparison of education of the survey respondents can be made with that of Tennessee homeowners. This issue lends to the fact that results could possibly be values biased.

It is the hope of the author that this information may be used to pacify the development community in regards to the Knox County SPR. It can be concluded that people would prefer BSD developments over conventional ones in terms of aesthetic quality. It could further be deduced that people would be inclined to purchase properties that incorporated such techniques. Further, those that responded so positively to the survey contained herein are those that would be presumed more likely and/or able to purchase properties. This is noted as a highlight for the development community. It is my contention that BSD would not only serve to enhance the quality of life through cleaner water, but it would enhance quality of life through sense of place and natural beauty.

Further research could include determination of a possible affinity for those of higher income and education levels to choose more "green" images. Additionally, the photographs could be more equal in terms of quality, color, and lighting. Finally, "scales" of preference may be utilized to determine to what extent respondents prefer the images.

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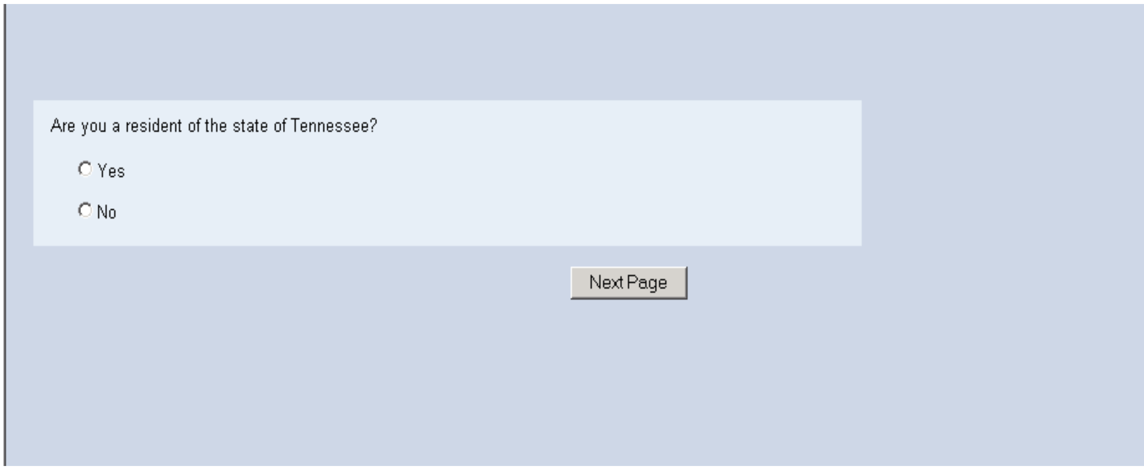
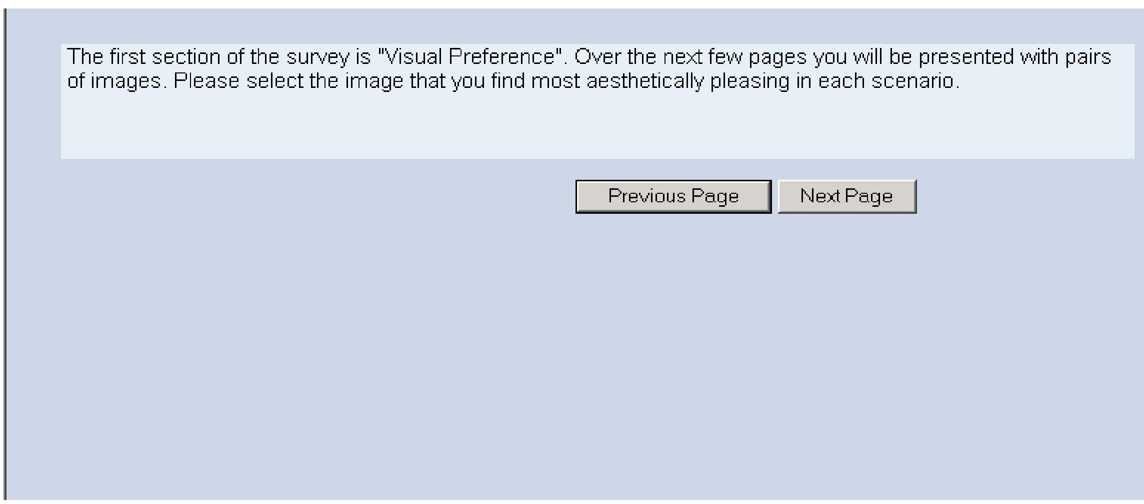
APPENDIX:
SURVEY AS IT APPEARED ON THE WORLD WIDE WEB


Are you a resident of the state of Tennessee?

○ Yes

○ No

Next Page


The first section of the survey is "Visual Preference". Over the next few pages you will be presented with pairs of images. Please select the image that you find most aesthetically pleasing in each scenario.

Previous Page Next Page

Overflow Parking Area

○ Image 1 ○ Image 2

Please select the overflow parking area that you find most aesthetically pleasing.

[Previous Page] [Next Page]

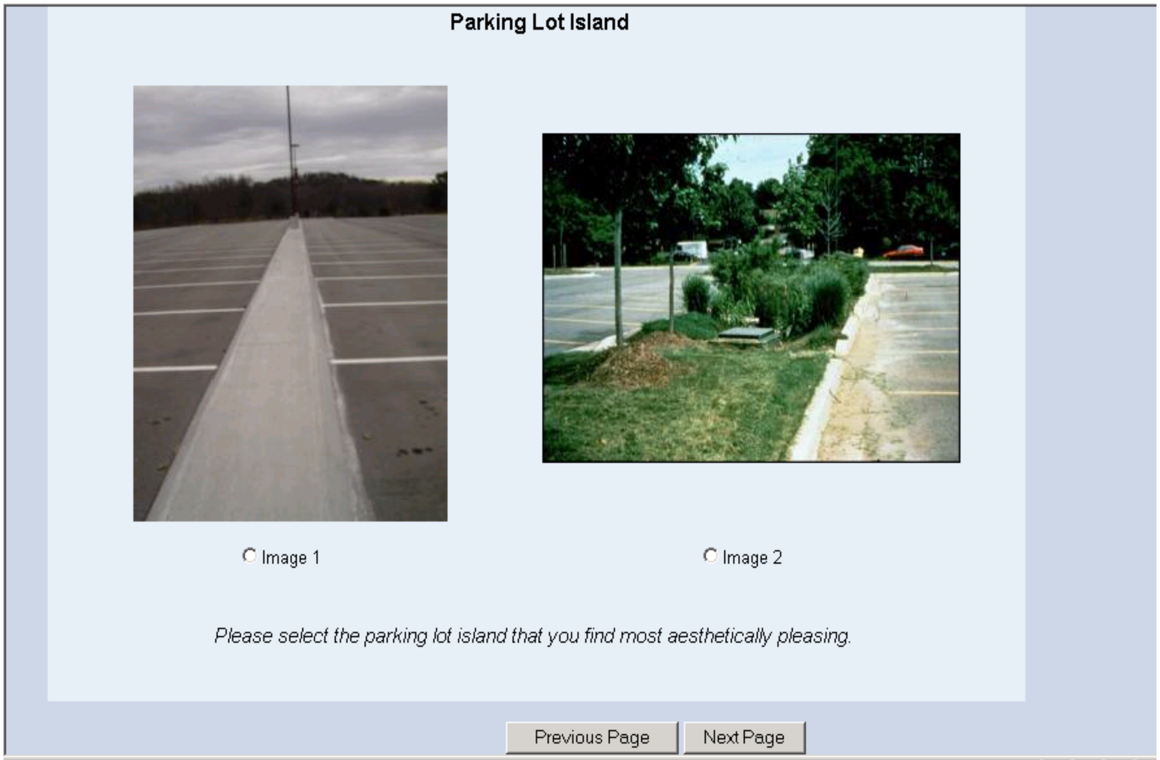
Cul-de-Sac

○ Image 1 ○ Image 2

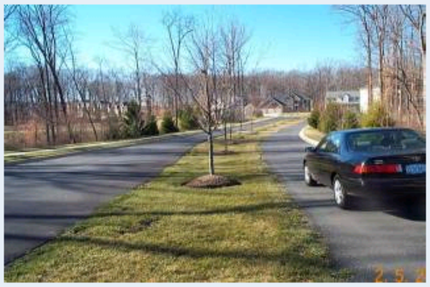
Please select the cul-de-sac that you find most aesthetically pleasing.

[Previous Page] [Next Page]


Driveway
Image 1
Image 2
Please select the driveway that you find most aesthetically pleasing.
Previous Page
Next Page


Parking Lot Island
Image 1
Image 2
Please select the parking lot island that you find most aesthetically pleasing.
Previous Page
Next Page

Street



○ Image 1 ○ Image 2

Please select the street that you find most aesthetically pleasing.

[Previous Page] [Next Page]

Vegetation on Lot

○ Image 1 ○ Image 2

Please select the housing lot that you find most aesthetically pleasing.

[Previous Page] [Next Page]

Subdivision Layout

○ Image 1 ○ Image 2

Please select the subdivision layout that you find most aesthetically pleasing.

Previous Page | Next Page

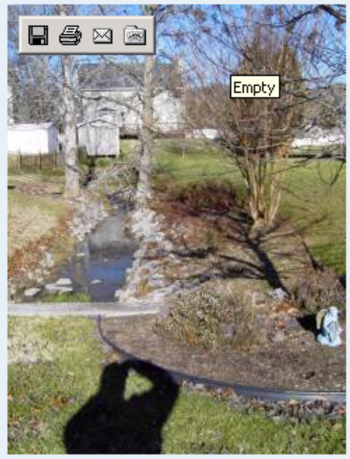
Neighborhood Ditch/Culvert

○ Image 1 ○ Image 2

Please select the ditch/culvert that you find most aesthetically pleasing.

Previous Page | Next Page

Stream Bank

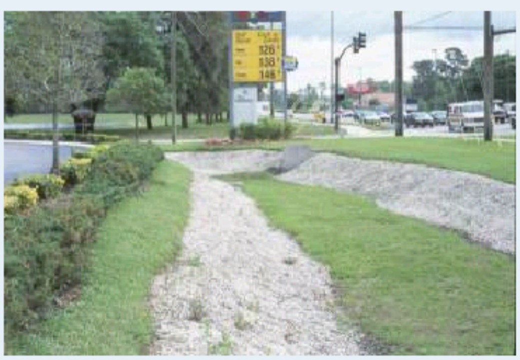


○ Image 1 ○ Image 2

Please select the stream bank that you find most aesthetically pleasing.

Previous Page | Next Page

Commercial Ditch/Culvert

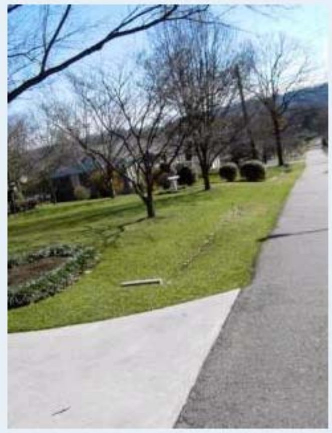


○ Image 1 ○ Image 2

Please select the ditch/culvert that you find most aesthetically pleasing.

Previous Page | Next Page

Stormwater Conveyance System



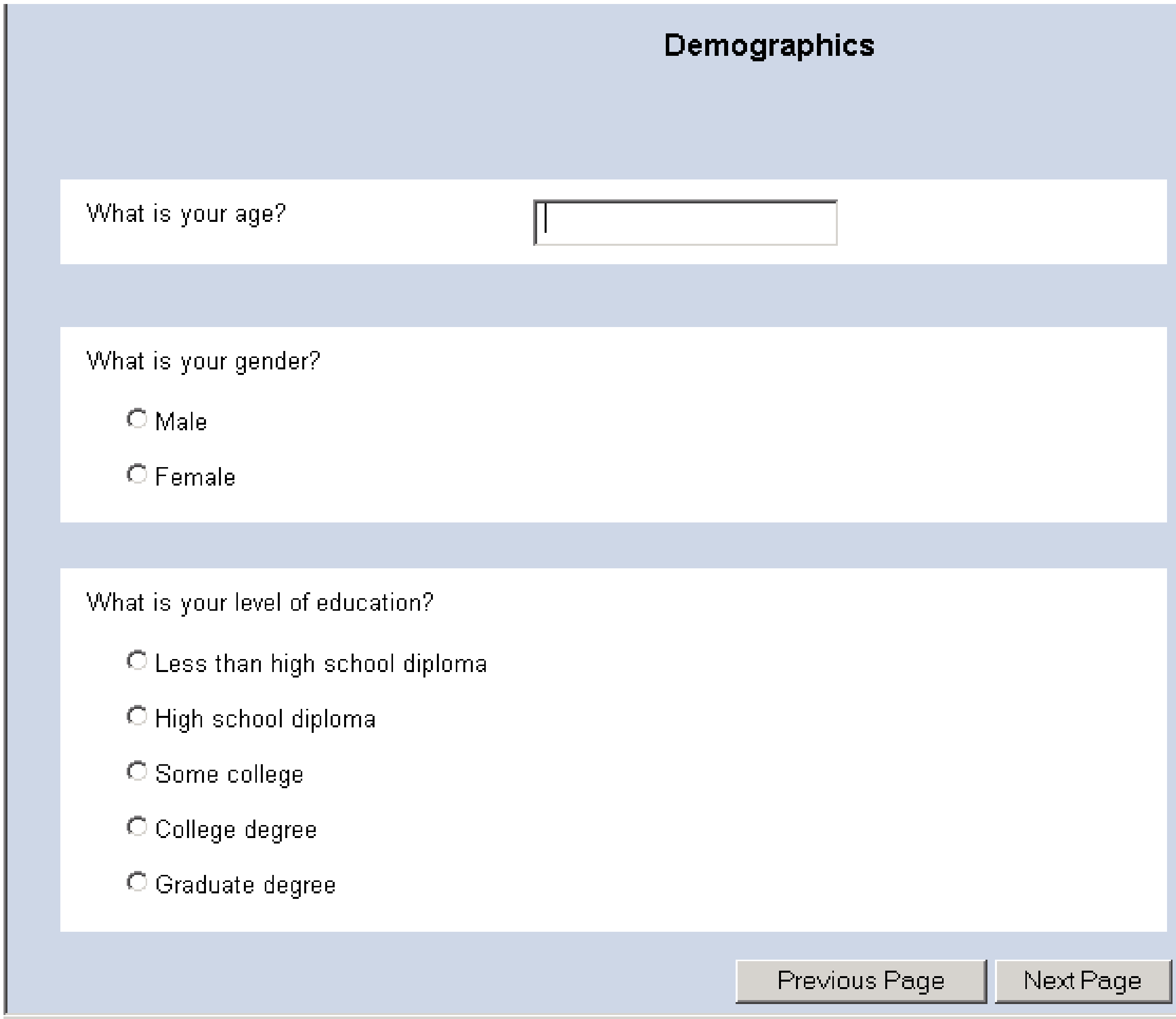
○ Image 1 ○ Image 2

Please select the stormwater conveyance system that you find most aesthetically pleasing.

Sidewalk Design

○ Image 1 ○ Image 2

Please select the sidewalk design that you find most aesthetically pleasing.



Demographics

What is your age?

What is your gender?

- Male
- Female

What is your level of education?

- Less than high school diploma
- High school diploma
- Some college
- College degree
- Graduate degree

Previous Page | Next Page

What is your marital status?

- ○ Single
- ○ Married
- ○ Divorced

What is your occupation? [ ]

What is your level of income?

- ○ Less than $18,000
- ○ $18,000 to $29,999
- ○ $30,000 to $49,999
- ○ $50,000 to $69,999
- ○ $70,000 to $89,999
- ○ $90,000 or higher

Are you a homeowner?

- ○ Yes
- ○ No

[Previous Page] [Next Page]

How many years have you owned your current home? ______ years

How many homes have you owned? ______ homes

What best describes your current housing type?

- ○ Single family, large lot (>.5 acre)
- ○ Single family, small lot (<.5 acre)
- ○ Single family condominium, small to zero lot
- ○ Multi-family condominium, no lot ("downtown" setting")

Choose your ideal preference.

- ○ Suburban large lot (>.5 acre)
- ○ Suburban small lot (<.5 acre)
- ○ Single family condominium, small to zero lot
- ○ Multi-family condominium, no lot

[Previous Page] [Next Page]

How likely are you to purchase property in the next 10 years?

- ○ Very Unlikely
- ○ Unlikely
- ○ Unsure
- ○ Likely
- ○ Very Likely

Additional Comments

Please click Send Answers to submit your responses. Thank you for your participation.

[Previous Page] [Send Answers]

Vita

Born and raised in Memphis, TN, Lee Blackburn knows very well what it means to live in the concrete jungle. Lee was born in 1977 and spent his entire childhood in the suburbs of Memphis. At 18 he graduated from Christian Brothers High School and moved to Knoxville where he received his Bachelor's degree in Forestry from the University of Tennessee in 2000. He married Abby Griffiths then spent the next 2 years of his life in the Teton Mountains of Idaho trying to find himself, which he probably never will. But he did decide it was time to move on and tie his shoes, so to speak. As an avid lover of the outdoors, especially fishing and whitewater, he was determined to have a professional association with some element thereof. He received an MS in Urban and Regional Planning with an environmental concentration from UT in 2004 with a focus on water resources, and his primary aspirations are to have loving children and save the world.